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Coal Storage With Portable Conveyors

PRINCIPLES UNDERLYING THE POLICY OF STORING COAL; PRACTICAL DIFFICULTIES ENCOUNTERED; EQUIPMENT USED IN PREVENTING AND FIGHTING FIRE. BY ROBERT F. HAVLIK*

LOCATED ON the bank of the beautiful Fox River, in the famous dairy districts of northern Illinois, about 37 mi. west of Chicago, is a community known as Mooseheart, inhabited by 900 people, principally children of all ages from babies to young men and women. It covers an area of 1014 acres on which are located 55 dormitories and school buildings, all of which are heated from a central heating plant which also provides electricity for power and light. This plant is equipped with four water-tube boilers with a total capacity of 1630 hp. and consumes about 11,000 tons of slack coal annually.

When the increasing difficulties of railroad transportation made it impossible to get our coal as we needed it we invested in portable conveyor equipment to meet the emergency. The necessity of storing more coal each year finally brought us to a point in the early fall of 1919 where we had again greatly to increase our storage capacity.

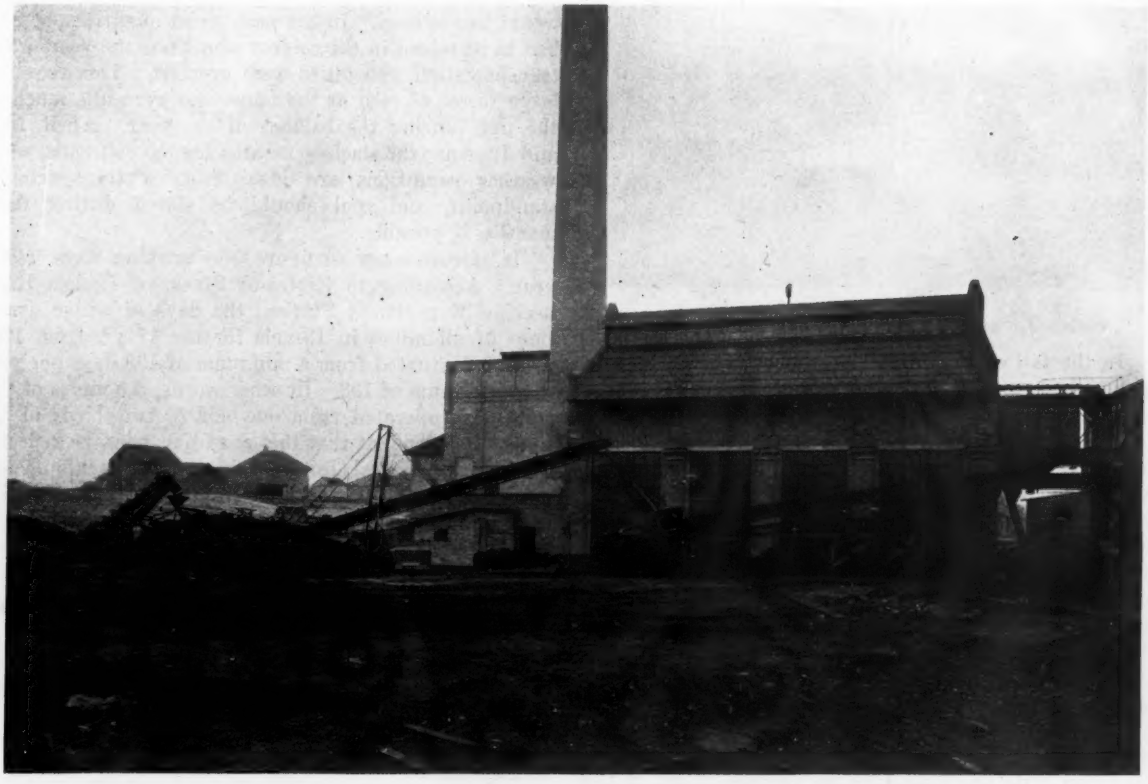

FIG. 1. GENERAL VIEW OF PORTABLE CONVEYOR EQUIPMENT AT MOOSEHEART

The problem of coal storage involves another of no less importance, which is fire prevention and control, and this has always given users of large quantities of coal considerable trouble. The system we use simplifies

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the problem greatly. On a recent trip through the East, it was my good fortune to visit some large power plants and learn their experience along these lines and what I learned confirmed me in the belief that our system of coal storage offers one of the best solutions for this vexing problem to all users of bituminous coal who store it in quantity.

Previous to 1915, coal for power plants was not stored in any great quantity except by the big public utilities companies. A storage sufficient in capacity to run a plant for 30 days in an emergency was considered ample for most purposes. For the average user, this meant a small amount of coal relatively, and the cost of storing and reclaiming, although high enough per ton, did not run into sufficient money to justify a large expenditure for storage equipment of a permanent nature. Conditions have changed materially, however, since that time, and for each ton of coal that was stored previous to 1915, there have probably been two or three tons stored in the last two or three years. There are two reasons for this: Strike dangers and the difficulties of railroad transportation, at certain seasons of the year, particularly during the winter months when the demand for coal is greatest.

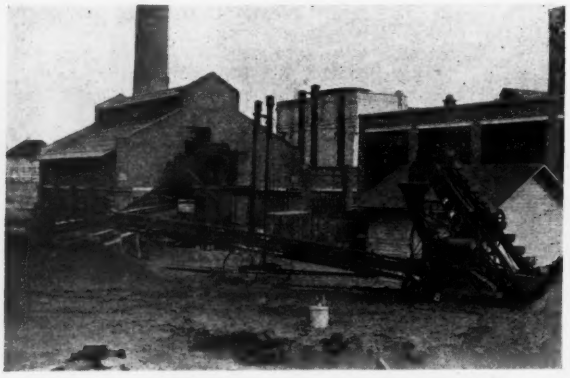


FIG. 2. RECLAIMING COAL AT MOOSEHEART

In the fall of 1916, the coal miners made their first serious move toward a general strike. This, fortunately, did not materialize, but in spite of that there was a tremendous coal shortage throughout the winter of 1916 and 1917. Threats of strikes by coal miners came periodically from then on until the actual strike of last fall which paralyzed industry throughout this nation. The unrest in railroad circles almost resulted in a strike in the fall of 1916 and the nation has been on the verge of a railroad strike, periodically ever since. For this reason, coal users everywhere have found it expedient to store ample quantities of coal to tide them over the probable periods of strikes of either railroad workers or coal miners.

Second only to the ever impending labor difficulties, is the inadequacy of railroad facilities today. This is a condition little understood by the average citizen of this country. The tremendous increase in the production of our industries in the past decade and particularly since 1915 and the consequent increased demand on our transportation systems would probably have been serious, had the railroads not been hampered in any way in their efforts to keep pace with the demands on their service.

According to Edward Hungerford, the increase in traffic based on tonnage hauled per mile since 1915, has been about 10 times as great as the increase in the number of cars, which means that the railroads are endeavoring to handle the vastly increased traffic of today with the equipment of 1915. The gain in cars during this period has been 120,000, against a normal requirement of 700,000 cars, and this alone is the greatest cause of the tremendous car shortage of today.

Increasing minimum carload tonnages and overloading cars wherever possible by approximately 10 per cent has been a help, but conditions cannot return to normal until the rolling stock is replenished. This can scarcely come about in less than 5 yr. For a long time, the shortage of railroad equipment is bound to limit the construction and industrial activity of the country.

In addition to the motive of self preservation, we have also to consider the business of the country as a whole. Any measure that can be taken by the users of coal in this country to reduce the peak loads at the coal mines and on the railroads will be a valuable service. If coal is stored in spring and early summer, by the principal industries, when the domestic demand is light, steadier work will be provided for the miners, and a steadier demand on the railroad transportation facilities. If the demand for the coal at the mines could be made constant from month to month, instead of fluctuating, one of the greatest causes of labor difficulties at the mines would be removed. In the past, great quantities of coal had to be mined in the coldest months of the year, when transportation difficulties were greatest. This required large forces of men at the mine who were idle much of the time during the balance of the year. April, May and June are the slackest months for the railroads, when weather conditions are ideal from a transportation standpoint, and coal should be stored during these months, if possible.

It is customary to figure 300 working days to the year. According to Professor Stoek, of Illinois Engineering Experiment Station, the days of active operations of all mines in Illinois for the 17 yr. from 1900 to 1916 fluctuated from a minimum of 158 days per year to a maximum of 198. In other words, the mines of this state have operated from one-half to two-thirds of the time. It is evident that this condition must be reflected in the price of coal, for the miners must earn sufficient money during their working season to keep them during their idle time, and every effort to make the rate of mining uniform is bound to result beneficially to the consumer.

The reason for storing coal, as discussed above, may be briefly summarized as follows:

1. To assure the consumer a sufficient supply to protect him against labor troubles, at the mines and on the railroads.

2. To reduce the peak demands on the transportation systems.

3. To help create a uniform demand on the mines, thereby tending to reduce the price of coal.

Unfortunately, the storing of coal may result in spontaneous combustion unless special precautions are taken to prevent it. This is particularly true of the smaller sizes of coal commonly stored by power plant users. The

seriousness of this problem as it pertains to Mooseheart has caused the writer to make a careful study of coal storage and spontaneous fires and the prevention and control thereof.

Opinions as to the best practice for coal storage are almost as varied as the number of consumers who have stored coal in quantities. Professor Stoek has made a very careful study of all the available data on this subject and summarizes the information very satisfactorily in Circular No. 6, issued in March, 1918. Many of his statements have been borne out by my experience at Mooseheart.

Causes of spontaneous combustion frequently advanced may be grouped under these headings.

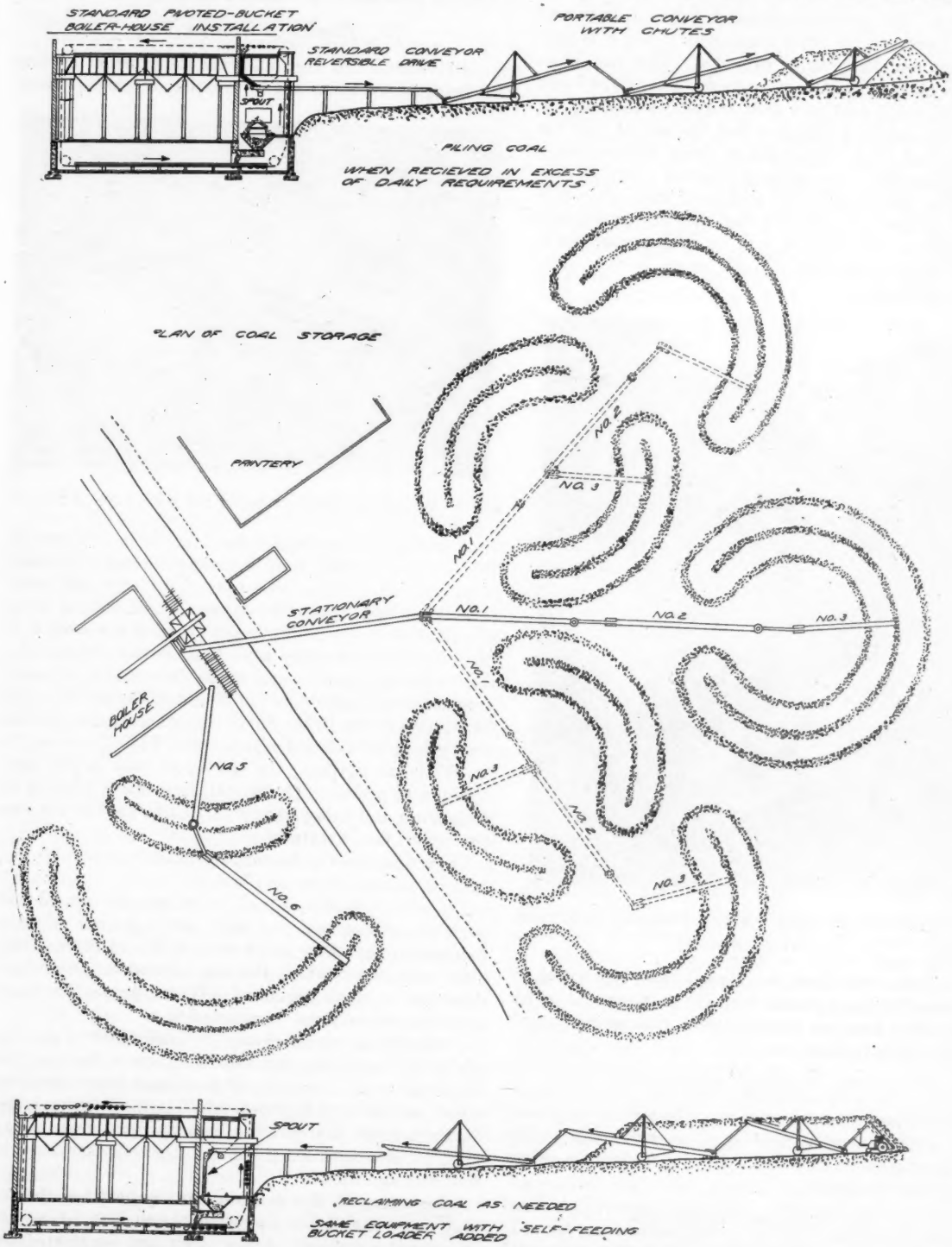


FIG. 3. PLAN OF COAL STORAGE PILES AT MOOSEHEART

I. Size of Coal

The development of automatic stokers has made it possible to burn the smallest sizes of coal, such as screenings passing a ¾-in. mesh and plants equipped with such stokers have used this coal in preference to larger sizes, the principal reason being the difference in cost.

Years ago this fine coal was sold at a very low price at the mines. The increasing demand, however, in recent years has increased the price considerably, but it is still the cheapest coal that can be procured. This size, however, is the most difficult to store on account of the large quantity of small coal and dust contained therein. A study of this question indicates that the size of coal has a greater effect on the likelihood of firing spontaneously than anything else. It is generally agreed that coal containing dust will usually fire within 90 days after it is stored. It is also a well known fact that any bituminous coal is likely to have dust in it in its final storage condition, due to handling, firstly at the mines, and secondly at the point of storage.

FIG. 4. VIEWS OF CONVEYOR FOR TRANSFERRING COAL FROM CAR PIT TO STORAGE

The best authorities are agreed that large coal or screenings that have passed over 1½-in. mesh and which are free from dust can be stored with little or no danger of spontaneous combustion.

II. Varieties of Coal

More than one variety of coal should not be placed in the same pile, as the coal which is most liable to fire from spontaneous combustion may jeopardize the safety of the other grades.

III. Lack of Ventilation

It has been claimed that lack of ventilation in coal piles will cause fires. Extreme ventilation may prevent spontaneous combustion, but a little ventilation is much worse than none at all and it is so expensive fully to ventilate a pile of coal that this is practiced very little in this country. From past experience, we know that the results desired can be secured without assuming the large expense of a complete ventilation system, and, while this may have its merits, it will not be considered in this article as a means of prevention or control of fires.

IV. Height of Storage Piles

The theory that high piles are the cause of heating and firing is not borne out in practice, because as many

FIG. 5. CONVEYOR USED WITHOUT PIT FOR LOADING TRUCKS

fires start on the surface of the piles as in the interior. While it may be that heat is cumulative and is radiated from the center of the piles toward surfaces and breaks into flames there where the oxygen is available, it is also true that fires have broken out in piles not over 8 ft. high. It is advanced by some that the coal crushes and that the resulting dust causes the fire; but the crushing does not seem possible, as the weight of the coal in a pile 50 ft. high is but 18 lb. per sq. in., whereas the crushing strength of bituminous coal is about 1300 lb. per sq. in.

While we advocate the storing of coal in low piles, it is not to prevent fire, but rather to make possible the reclaiming and using of any particular part of the storage where fire threatens.

In storing coal and guarding it while in storage, certain precautions must be taken.

1. Since the size of coal, or to be more specific, the presence of fine coal and dust, has a greater effect on firing than any other single item, it should be very carefully considered where the size of coal or presence of dust can be at all regulated. Where prevention is not possible, control must be resorted to.

Storage equipment should be used which is the least likely to break the coal into small particles and thus create fine coal or dust. I have had experience with coal that has been screened over 1¼-in. mesh or larger. In these cases, the coal has been dropped from a large trestle and undoubtedly some of it was broken, creating fine coal and dust.

Screenings as fine as ¾-in. usually heat and the only way to prevent a fire is to move the coal, as I have done on several occasions. A few years ago, we started storing a fine washed coal ranging in size from ⅛ to ½ in.

This coal contained no dust and did not fire in piles up to 20 ft. in height. This was piled with a portable belt conveyor in a series of conical piles, the discharge end of the conveyor was placed as close to the pile as possible, thus reducing the drop to a minimum and preventing breakage of the coal. This resulted in the coal being stored in practically the same condition as that in which it was received, namely free from dust. I believe this was the sole reason that it did not fire.

During the past winter we had to store a much greater quantity of this than ever before and in a very short period, and we were forced to pile it in high piles and although it heated, it did not fire except in a few instances where slight fires occurred. On investigation, it was found that in each case the source of trouble was that small pieces of wood had been buried in the coal. When these were removed, no further trouble with fire was encountered.

To secure sufficient coal, we had to store some unwashed ¾ and 1½-in. screenings and both fired spontaneously and gave us considerable trouble. Unfortunately, we did not have sufficient space or equipment to repile this particular coal. Such a procedure would have stopped the fire as it had on similar occasions in other years.

It is not often possible to choose between two grades of coal, one containing dust and one free from dust, but it should be borne in mind that there is a strong argument in favor of the coal free from dust.

Whatever coal is received should be handled by equipment which will not increase the amount of dust already in the coal. This is a very important matter and one which I feel we have solved by the use of portable belt conveyors.

2. In one group may be placed the minor precautions such as piling of only one grade of coal in one pile, packing the surfaces of fine coal to exclude oxygen, storage under water where space and expense permit, thorough ventilation of the whole pile, through vents spaced very close together, and other minor precautions which are usually rendered impractical by other considerations.

3. One of the most necessary steps to take in the guarding of stored coal is to take periodical readings of the temperature. Pipes should be placed in the storage pile at frequent intervals so that a maximum reading thermometer can be inserted and the temperature taken periodically to ascertain whether or not there is any excessive heating. When the temperatures rise to about 120 deg. F. they should be taken daily and when they reach 150 deg. F. the piles should be moved to another location if possible, to prevent firing.

4. In order to move a pile of coal where firing threatens, considerable thought must be given before the storing is done, and while it is in progress. We give a great deal of attention to other precautions; but since any or all of these may fail, we are most particular in the arranging of our storage piles so that it will be possible to use in the power plant or repile any coal which is threatened.

The most important considerations in the choice of systems for the average plant are as follows:

A. Storage capacity.
B. Initial cost of plant.
C. Cost of operation, including maintenance.
D. Utilizing equipment already installed as far as possible.
E. Minimum breakage.
F. Flexibility of system, permitting of easily reclaiming and transferring in case of need, to prevent fires.

In seeking a solution of this problem for Mooseheart, I found that portable belt conveyors were particularly adapted to this purpose and satisfactorily met all of the foregoing considerations. They are lower in first cost, can be added to, unit by unit, to take care of additional capacity if needed, low in cost of maintenance, cause the least breakage of coal, and are particularly adapted for use with our regular boiler-house equipment. Most important of all is their flexibility, permitting the easy moving or reclaiming of any particular part of the coal stored. Although this equipment is by no means a "cure-all" for storage problems, it takes care of our difficulties most admirably and offers many new and interesting applications. It will lend itself readily to the storing of coal over wide areas and permits reclaiming readily, and has an operating cost about the same as the operating cost of much more expensive machinery.

Wheelbarrows and shovels have formed the principal storage equipment in small plants, but the present high cost of labor makes this method very costly. In 1914-1915, we stored but a small quantity of coal and unloaded the coal from the cars by hand on to a storage pile adjoining the track; but when we found it necessary to store larger quantities, this was found too costly. An investigation of the matter led me to believe that portable belt conveyors were most suitable for our requirements, and accordingly we installed the first unit in 1915. Since then, we have added to the equipment until we now have two 60-ft. portable conveyors, one stationary 120-ft. conveyor, one 60-ft. combination portable conveyor which is now bing used as a stationary conveyor, also one self-feeding type loader as shown in Figs. 1 and 2. We expect to add two more portable conveyors this year to complete our equipment.

Our coal comes in bottom dump cars and is dumped into a pit directly under the track whence it is fed to a pivoted bucket conveyor system. Fortunately we have sufficient space between the ash hopper and the main building to permit the dumping of the coal into a chute, which discharges the coal onto the stationary conveyor. From this it can be placed in the various piles indicated in Fig. 3 by means of the portable conveyors No. 1, No. 2, and No. 3. The system is so flexible that the storage capacity can be increased indefinitely by additional conveyor units. The portable conveyors are mounted on swivel trucks and are supported on masts such that the discharge end of the conveyor can be raised or lowered at will to any desired height, within the limit of the machine. This permits setting the discharge end of the conveyor so that it nearly touches the top of the storage pile. The coal then drops such a short distance that it reaches the pile in practically the condition in which it leaves the car. The breakage with this equipment is undoubtedly less than with any other type of equipment. The swiveled wheels permit of the easy movement of the discharge end of the conveyor. The storage piles are triangular in cross section.

When the coal is reclaimed, the self-feeding loader is used to transfer the coal from the storage pile to the first conveyor. The positions of the conveyors are reversed as shown, and the belt of the stationary conveyor is run in the reverse direction so that the coal is discharged from this into the track hopper whence it is conveyed by the pivoted bucket conveyor to the overhead storage bins in the boiler room.

We have found from experience that two men, one at the car and one at the conveyors, can easily unload three 50-ton cars in 8 hr. This makes the labor cost less than 7 ct. per ton. With the self-feeding type loader, the coal can be reclaimed at approximately the same cost.

During a recent visit to some plants where large quantities of coal are stored in the East, I was agreeably surprised to find that their storage costs with clam shell buckets and other expensive equipment were no less than ours. The maximum capacity of 18-in. belt conveyors such as ours, is approximately 60 tons per hour, which is equivalent to 480 tons in 8 hr.; but it is always found that under actual working conditions, considerable time is lost in placing cars and moving empty cars, all of which reduce the average hourly capacity.

On account of the great flexibility of this system, it probably offers the best solution for long time storage for the average plant. It is reasonable in cost and can be enlarged as needed at small expense. Its very flexibility adapts this equipment for storing coal under almost any conditions. For example, it is not necessary to feed the portable conveyors with regular track hopper equipment. Coal can be dumped from bottom dump cars direct to one of these conveyors. In such cases, the charging end is placed as close to the track as possible and only one hopper or door of the car opened at one time. Frequently a shallow pit is dug, 18 in. or more below the top of the ties. This may be concreted, but usually is not. The wheels may be set crosswise of the conveyor, so that the conveyor can be moved readily from one hopper to the other as needed. Most of the coal will feed directly to the conveyor. In side-dump cars, the hoppers on the other side of the car will have to be shoveled by hand. What spills on the ground will also have to be shoveled by hand, but this is relatively small and I have been surprised to learn that cars have been unloaded by this method by two men in 2 hr. time.

The method just mentioned is illustrated in Fig. 4, which shows a 39-ft. conveyor used by the Lawrence Park Heat, Light and Power Co., Bronxville, N. Y. Although this conveyor has been in use several years, it showed very little wear when seen by the writer recently. When it is planned to handle mine run coal, as shown in this figure, it is necessary to use small cleats on the belt. The space below the track in this case is lined with concrete. It will also be noted that the trucks are not used in this case, the conveyor being suspended by an overhead cable.

Figure 5 shows a belt conveyor used with a standard dump car and the conveyor is shown resting on the ground, no pit being provided.

Another use made of this equipment is in connection with locomotive cranes. Cranes in piling to their maximum reach, allow the coal to flow under its natural angle of repose to a distance beyond reach of the crane. A belt conveyor can convey this back within reach of the crane. This conveyor can be loaded by hand, or by the self-feeding loader. Such a combination is shown in Fig. 6, which shows several conveyors and a self-feeding loader used in this manner by the United Electric Company at Springfield, Mass. This equipment can be adapted to almost any situation and should prove a boon to small coal users where the cost of older styles of equipment would be out of the question.

FIG. 6. RECLAIMING COAL WITH PORTABLE CONVEYOR WHICH HAD BEEN STORED BY LOCOMOTIVE CRANE

Fire Prevention and Control

As stated previously, one of the most important advantages of this kind of equipment is in connection with fire prevention in storage piles, also for fire control where fires have already been started. It has been successfully used for this purpose in Eastern plants which the writer saw during his investigation. In one instance

the fire had gained such headway that it was impossible to use the overhead storage equipment or the underground reclaiming tunnel and two portable belt conveyors solved the problem as shown in Fig. 7.

Another advantage reflected in the actual cost to the user is the fact that these portable conveyors require no permanent foundation. Oftentimes the supporting framework for overhead storage devices is destroyed by coal fires. Nothing like this is likely to occur in connection with the portable conveyors as they can be moved out of danger.

The plant shown in Fig. 6 stored approximately 9000 tons of coal for the first winter. About 90 days after the coal was stored, a fire broke out in one portion of the pile. The loader and portable conveyor were brought into use and the coal in that portion of the pile was quickly transferred elsewhere or burned in the boilers. A path was cut right through the pile and the spreading of the fire prevented. As this particular pile was beyond the reach of the clamshell equipment, it would have been impossible to prevent the spreading of this fire, or to control it by any other means available.

On the basis of our past experience and supported by the evidence which I gathered on my trip of inspection, I feel sure that we have started with the proper kind of equipment for the storing and reclaiming of coal, and have a most efficient plan for the prevention and control of fires.

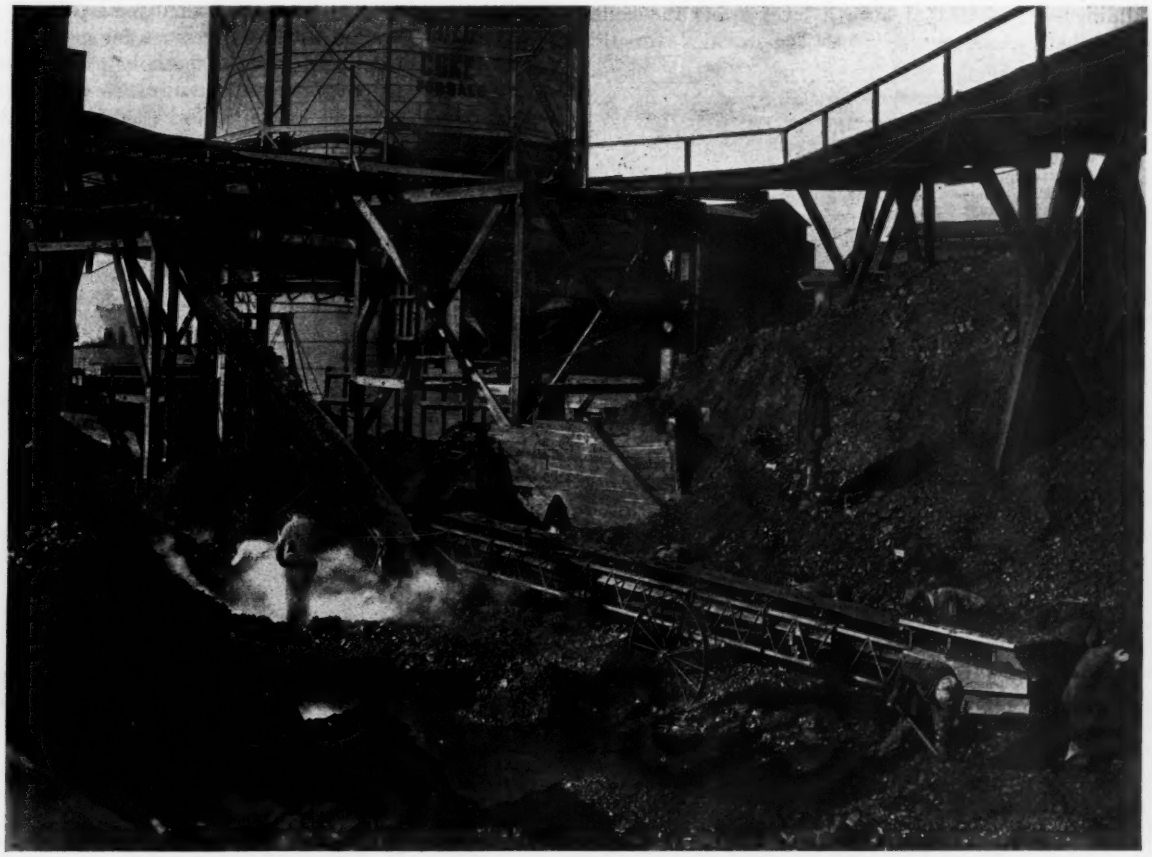


FIG. 7. PREVENTING SPREAD OF COAL PILE FIRE BY MEANS OF PORTABLE BELT CONVEYORS

Is Lime a Belt Treatment?

By W. F. Schaphorst

A PRACTICE that should be discouraged among belt men is the use of lime on oily belts. It is thought by some that nothing is equal to lime for absorbing oil and rendering the belt fit to do its work. Under oily conditions, however, almost any dry powder will make a belt pull better—anything that will absorb the oil. A non-corrosive powder, however, should rather be used, such as chalk or Fuller's earth. But, better still, don't use any powder at all.

In emergencies it is often considered good practice to "do anything in order to get out the work," but that does not imply that we should keep on doing it year after year. If oil continues to spatter on the belt, the belt man is bound to have more or less trouble right along, and he must keep on using this harmful expedient. Naturally, the belt won't last long under such severe conditions. The best treatment for an oily belt is to stop the oil spattering first and then keep the belt in good pliable condition. I know of no circumstances where oil throwing cannot be stopped. After that is done, I would wash the belt clean of the oil and then fill it full of the best belt treatment obtainable. Do not use castor oil, neatsfoot oil, boiled linseed oil, etc. Use a treatment that is made especially for belts by a responsible manufacturer.

Handling Condensate---II

METHODS APPLICABLE TO POWER AND HEATING PLANTS. BY CHARLES L. HUBBARD

WE will now take up a few of the unusual conditions which occur from time to time and which are often difficult to handle satisfactorily. There are many of these, varying more or less in different plants.

While in most plants it is possible to return the condensation from the heating system directly to the receiving tank in the boiler room, either by gravity or by lifting it to the necessary height by the low steam pressure carried in the system, there are cases where one or more buildings are located at such a level *below* the boiler house that special means must be provided for this purpose.

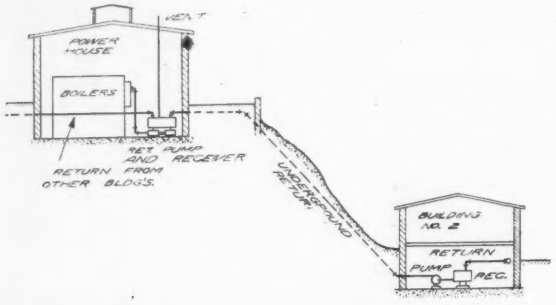


FIG. 11. MEANS PROVIDED TO RAISE CONDENSATE TO BOILER ROOM LEVEL

Figure 11 shows in diagram a condition of this kind in which "Building No. 2" may represent either a single building or the lowest one in a group located considerably below the power house.

In cases of this kind, the returns from those buildings which are sufficiently elevated may be brought back to a vented receiver in the usual manner as indicated by the pipe line coming from the left in Fig. 11. The returns from the lower group should be brought to a receiving tank in the basement of the lowest building, and from here pumped back to the main receiving tank in the boiler house. The best type of pumping equipment will depend somewhat upon circumstances. If this building is piped for high pressure steam for other purposes, then the simplest and probably most economical arrangement will be to employ an ordinary automatic steam pump and receiver, and pass the exhaust through a small oil separator into the heating system of the building. A pressure of 15 lb. will often operate a pump of this kind by using an extra large steam cylinder in proportion to the water cylinder. In determining the relation between the piston areas, the total force acting on the steam piston with the available pressure should be sufficient to overcome the friction of the pump, the resistance of the pipe line to the flow of water, and to lift the condensation the required height to the main receiving tank. In general, for cases of this kind, it is best to give all of the conditions, as to quantity of water to be handled, distance to power house, lift, and the available steam pressure, to the makers of the pump it is proposed to use and let them fix the size and relative cylinder proportions.

If the lower building is not connected for steam, other than the low pressure used for heating, it will usually be best to employ an electric pump as shown in the drawing, rather than run a special line of high-pressure steam to the building.

Another method of returning condensation under similar conditions is by means of a return trap. This requires high-pressure steam for lifting the water, but the friction of the machine is less than for a pump, and can therefore be used with less pressure for a given lift where it is not desired to use a specially proportioned pump. It is also more convenient in cases where there is a single building of this kind to be cared for, being entirely automatic in its action and requiring no special attention. Under ordinary conditions, it is made to discharge into the main receiving tank in the boiler room the same as the pump shown in Fig. 11. An arrangement for putting condensation directly back into a boiler without the use of a return pump is illustrated in Fig. 12. Cases of this kind are not common about a power plant, where return pumps and receivers are usually

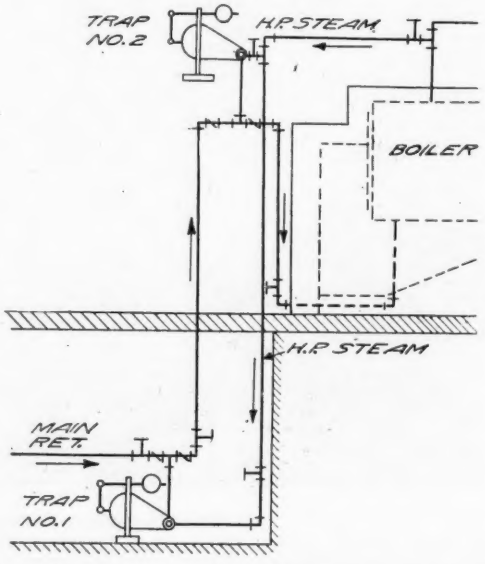


FIG. 12. ARRANGEMENT FOR PUTTING CONDENSATE BACK INTO BOILERS WITHOUT USE OF RETURN PUMP

employed, but might occur in a heating plant run at a lower pressure, where the buildings were arranged as in Fig. 11, or where it was necessary to lift the water a height above that possible with the pressure carried in the heating system, a condition which might occur in the same building, as shown in the cut. In this case, all condensation is drained by gravity to trap No. 1 which is located at the lowest point in the plant. From here it is lifted by a higher pressure to trap No. 2 which returns it to the boiler in the usual manner. All pipe

connections are clearly shown in the cut and require no special explanation.

The use of forced hot-water heating in large plants, where both live and exhaust steam are used for heating the water, brings up special problems in the handling of condensation at different pressures and temperatures.

When the entire water heating is done by exhaust steam, which has been passed through an oil separator, the condensation from the heater is discharged directly into the hot-well or main receiving tank and returned to the boilers by the feed pump. If the pressure in the heater is always kept above that of the atmosphere, the condensation may be handled by an ordinary steam trap; but if it is liable to drop below atmosphere, as is sometimes the case, either a return trap or pump must be used for discharging the water into the hot-well against atmospheric pressure.

When live steam is used in small quantities for supplementing the exhaust, it is discharged into the heater automatically, as needed, through a reducing valve and the condensation disposed of with that from the exhaust. If, however, live steam is required in any considerable

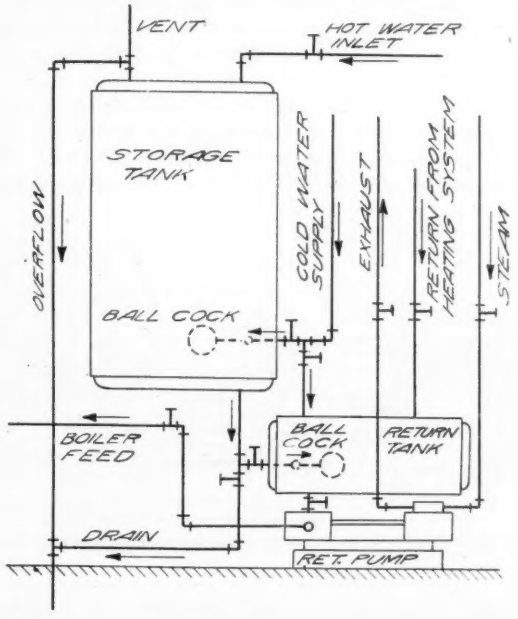


FIG. 13. MEANS FOR FEEDING HOT PROCESS RETURNS TO BOILERS

amount, it is more economical to employ an independent heater and return the condensation to the boilers by gravity. If trapped to the hot-well or a vented receiver, part of the water will break into steam upon release from the higher pressure and so pass through the vapor or vent pipe as waste heat. Sometimes, when live steam is required only in extreme weather, the condensation is trapped into the exhaust heater where it is re-evaporated at the lower pressure.

It sometimes happens in manufacturing plants that considerable quantities of hot water are available at irregular periods, as from steam presses or other mechanical processes. This water may often be utilized for boiler feeding by an arrangement similar to that shown in Fig. 13.

A large storage tank, either vertical or horizontal, is placed above the usual pump and receiver and provided with an overflow and vent. The hot water supply enters the top, and the bottom of the tank is connected with the pump receiver by means of a ball-cock which admits water to the receiver as needed. When the hot-water supply is insufficient for boiler requirements, cold water is admitted to the storage tank through a ball-cock located near the bottom.

Figure 14 illustrates a case which frequently comes up in combined power and heating plants and is well worth mentioning in the present connection, although it

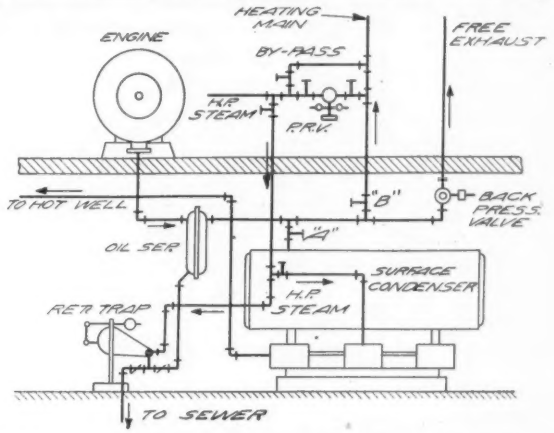


FIG. 14. CONNECTIONS PROVIDING FOR CONDENSING OR NON-CONDENSING OPERATION OF ENGINES

does not relate wholly to the disposal of condensation. In plants where all or a large proportion of the exhaust steam is utilized during the heating season, it is a matter of economy to run the engines condensing during the summer when the exhaust would otherwise be thrown away. When the heating plant is in use, valve A, leading to the condenser, is closed and B opened, which allows the exhaust from the engine to pass into the heating main instead. By closing B and opening A, the conditions are reversed ready for summer use.

As the oil separator is under a partial vacuum when the condenser is in use, it is necessary to employ a return trap with a high-pressure connection to discharge the drip against atmospheric pressure. While this type of trap is not necessary when the heating system is in use, it works equally well under this condition. The condensation from the heating system passes to a receiving tank and is returned to the boilers in the usual manner without reference to the special equipment shown in Fig. 14. The condensate from a surface condenser should be discharged into a hot-well and then fed to the boilers after being diluted with about 10 per cent of raw or fresh water to prevent corrosion. The discharge from jet condensers, which is partially warmed by the condensate, may be used for boiler feeding, provided the cooling water is of suitable quality and the oil removed from the exhaust steam before it enters the condenser.

As more or less has been said regarding the method of connecting up pumps with other pieces of apparatus for the return of condensation, it may be well to give a little brief data on pump sizes for this purpose, as well as the various types employed and the method of operating them.

Both direct-acting steam pumps of the single cylinder type, and motor or turbine-driven pumps are used in connection with vacuum heating. In case of small and medium size plants, the steam pump is more frequently employed; while it is wasteful in the use of steam, it is simple in construction and operation and easily regulated to secure the desired vacuum. If the supply of exhaust steam falls short of the heating requirements the large steam consumption is not important, as the exhaust can be turned into the heating system. If, on the other hand, the plant is of large size and there is an abundance of exhaust steam from the engines, motor-driven pumps will be more economical. Two complete

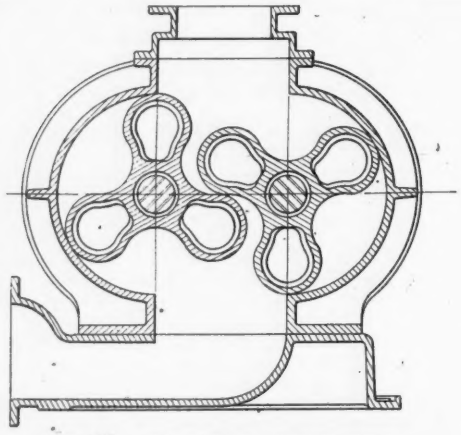


FIG. 15. SECTION OF ROTARY PUMP

pumping units should always be provided, each capable of doing the entire work, as a plant originally designed for vacuum heating will not usually work on gravity, even temporarily, on account of insufficient grading and the smaller sizes of the return pipes.

The proper size of pump depends somewhat upon the amount of radiation and the number of units. Single-cylinder pumps are commonly used for this purpose and may be proportioned from data given in the following table, which has been abbreviated from one given in "Combined Power and Heating Plants." While the proportions used by different makers vary somewhat, these dimensions will represent about the average for 100 lb. steam pressure.

TABLE OF VACUUM PUMP DIMENSIONS

Square feet of direct radiation	Diameter of steam cylinder, in inches	Diameter of water cylinder, in inches	Length of stroke, in inches
2,000	3	4	4
4,000	4	5	5
6,000	4	6	5
8,000	5	6	6
10,000	5½	6	7
12,000	5½	7	7
15,000	6	7	8
20,000	6	8	8
25,000	7	8	10
30,000	7	9	10
35,000	8	9	12
40,000	8	10	12

If the standard tapping for the pump suction is larger than the return main, it should be bushed down at the pump.

The rotary pump used for this purpose is commonly of the positive type, shown in section in Fig. 15, new designs embodying somewhat different principles have been put on the market more recently.

When this type of pump is employed it is necessary that it be placed at such a level that the condensation will flow into it by gravity.

Both reciprocating and turbine pumps are used for returning the water of condensation from the receiving tank to the boiler, a typical design of the former being shown in section in Fig. 16. The principal objection to this is the difficulty of detecting leaks around the piston and making the necessary repairs in case the water is gritty and cuts out the cylinder lining rapidly. This, however, is not so likely to occur in heating plants where the same water is used over and over again. If there is a possibility of this kind, a plunger pump is to be preferred, as a bushing is cheaper and more easily installed than a cylinder lining. For feed pumps, where there is likely to be excessive wear, the outside-packed plunger is the most desirable because leaks are easily detected and the plungers re-packed from the outside without dismantling the pump. A section and elevation of a water cylinder of this kind are shown in Figs. 17 and 18 respectively.

The quantity of water to be handled by a return pump will depend somewhat upon the size of the plant and the relation between the total quantity of steam generated by the boilers and that used in the heating

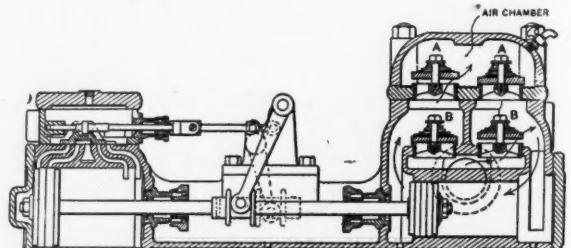


FIG. 16. SECTION THROUGH RECIPROCATING TYPE CONDENSATE PUMP

system. When all, or a large proportion, of the exhaust steam is utilized for heating, and the amount of make-up water is small, it is customary to admit it to the receiving tank and return it to the boilers with the condensation, in which case the pump capacity should be proportioned on the boiler power rather than on the amount of radiation. The pump, under these conditions, is a straight feed-pump and handles all of the water required by the boilers.

On the other hand, if the power requirements are large as compared with the heating, and a considerable amount of exhaust is thrown outboard, then a larger quantity of make-up water will be necessary and it may be best to return the condensation to the boilers continuously by an automatic pump, and supply the additional feed water, as needed, by a separate outfit.

When boiler capacity is the basis of computation, the weight of water to be handled per unit of time is easily

determined and reduced to gallons or cubic feet, allowing 30 lb. per hour per boiler horsepower for *normal* operation. If the boilers are forced beyond this, the pump capacity should be increased accordingly.

When the heating surface is made the basis of computation, we may assume about 0.3 lb. of condensation per square foot per hour for directing radiating surface, 0.5 lb. for indirect, and 1.7 lb. for hot-blast coils. As the capacity of a pump is usually rated in gallons, pounds of water may be reduced to gallons by dividing by 8.3. For example, a heating plant containing 5000 sq. ft. of direct radiation, 1500 of indirect, and 2500 of hot-blast surface will condense

$$5000 \times 0.3 = 1500$$
$$1500 \times 0.5 = 750$$
$$2500 \times 1.7 = 4250$$

6500 lb. of steam per *hour*, requiring a return pump having a capacity of

$$\frac{6500}{8.3 \times 60} = 13 \text{ gal. per } \textit{minute}.$$

A 200-hp. boiler plant, running at 30 per cent overload, would require a feed pump having a capacity of

$$\frac{200 \times 1.3 \times 30}{8.3 \times 60} = 16 \text{ gal. per minute.}$$

The capacity of a "piston" pump, or the volume of water which it will handle in a given time, depends upon the diameter of the piston or plunger, the length of stroke and the number of strokes per minute. As the last two factors are more or less variable for a given diameter of cylinder, the most useful table for general purposes is one which gives the quantity of water discharged per inch of stroke for different cylinder diameters. Knowing this, it is a simple matter to multiply by the length and number of strokes in any given case. The following table has been made up on this basis and gives the results in gallons. It was published by the writer some time ago in Domestic Engineering, but seems worth repeating in the present connection for convenient reference, although much of the contained data can be found in various forms in certain trade catalogs.

TABLE OF CYLINDER CAPACITIES PER INCH STROKE

Diameter of pump cylinder, in inches	Gallons discharged per inch stroke	Diameter of pump cylinder, in inches	Gallons discharged per inch stroke
1¼	0.0053	4½	0.0688
1⅜	0.0064	4¾	0.0767
1½	0.0076	5	0.0850
1¾	0.0104	5¼	0.0937
2	0.0136	5½	0.103
2¼	0.0172	5¾	0.112
2½	0.0212	6	0.122
2¾	0.0257	6¼	0.133
3	0.0306	6½	0.144
3¼	0.0359	6¾	0.155
3½	0.0416	7	0.166
3¾	0.0478	7½	0.204
4	0.0544	8	0.218
4¼	0.0614	10	0.340

In case of a duplex pump, the volume of water as computed by the table must, of course, be multiplied by 2. Furthermore, there is always a certain amount of leakage around the piston and valves of a pump, called "slip," which must be taken into account. This will reduce the theoretical capacity a variable amount depending upon the amount of wear and the adjustment maintained. Well-made pumps, kept in good condition, should keep the slip within 20 per cent; that is, the actual capacity of the pump should be 80 per cent of the theoretical. It is evident that as the piston and valves become worn, the percentage of slip will increase.

The matter of slip is sometimes taken care of by counting on a low speed and neglecting leakage, in which case a size of pump should be chosen which will handle the maximum amount of condensation at a speed of

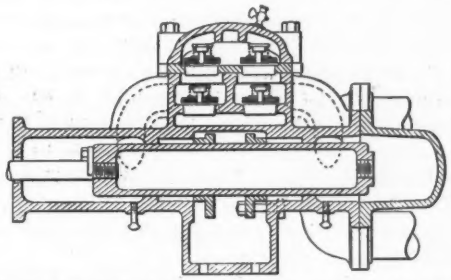


FIG. 17. SECTION THROUGH WATER END OF OUTSIDE PACKED PUMP

about 30 strokes per minute. This speed is much below the maximum of 100 ft. per minute sometimes allowed, but it is a good average for continuous work and allows sufficient leeway for any possible contingency in the way of leakage, etc. As in the case of vacuum pumps, there should also be a relay for returning the condensation to the boilers in case of accident or repairs to one of the units.

Electrically driven pumps of the type mentioned in connection with the layout shown in Fig. 11 may be either of the plunger, rotary, or centrifugal types, as may be considered most desirable for the case in hand.

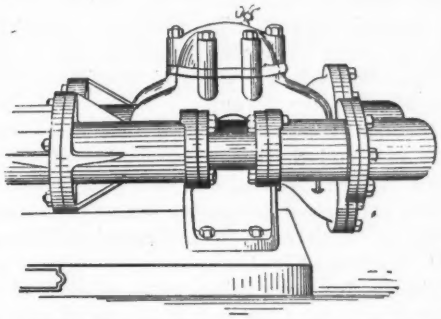


FIG. 18. ELEVATION OF WATER END OF OUTSIDE PACKED PUMP

Motor-driven pumps of the latter form and operated automatically by means of a pump governor or small tank and float which starts the motor when the water level reaches a certain point, may also be employed.

MANY articles are apparently brass, but are actually iron or steel brass plated. The easiest way to determine the material inside the coating is to touch the article with a magnet.

Baffle-Wall Development

IMPROVED FORM OF CONSTRUCTION INSURES A HIGH DEGREE OF ECONOMY. BY KINGSLEY L. MARTIN

IF you want to interest a power plant engineer, bring out a blueprint showing what some other fellow has done in setting his new boilers or resetting his old ones. Several things are responsible for this. In the first place, where the old idea was to get a number of small boilers and operate them at about 85 per cent of builders' rating, it is now customary to buy a few large ones and run them up to several times the builders' rating.

In the second place, the introduction of stokers has forced changes in furnace design never thought of a few years ago. Consider the bridge wall. It was in the way of the stokers and was pushed back out of the way, but retained to make all kinds of trouble, until one day some bright chap said: "See here, a bridge wall was put in to carry the back end of the grates in a hand-fired boiler, so why should I have a bridge wall?" Sure enough. Why? The bridge wall was thereupon retired so far to the rear that it merged with the rear wall as shown in Fig. 1.

In the meantime, other investigators had decided that while it was advisable to keep the bridge wall, even when pushed well to the rear to make room for the ever growing stoker, it would be a good scheme to abolish the lower part of the rear wall, put in a horizontal shelf below the second and third pass to form a convenient place for the soot to deposit (and, still more important, a convenient place from which to remove it). They also cut doors in the bridge wall through which the fire might be observed. This was also very convenient in covering up holes, breaking up clinker and generally working at the fire (Fig. 2).

Another engineer with equal disregard for precedent and driven to desperation by the unseemly behavior of the standard upright bridge wall, bethought himself of the expedient of sloping the face of the wall well to the rear as shown in Fig. 3. The result was so satisfactory that the operating force rose in arms when it was proposed that they were to return to the former arrangement on a new boiler layout.

Independently, combination of the bridge wall and the rear wall and the backward sloping of the bridge wall face has been worked out, and this design if provided with convenient means for removing the soot that inevitably accumulates on the horizontal shelf, has many desirable features (Fig. 4).

While this has been going on in stoker-fired boilers, a similar development has been made possible by the new development in baffle-wall construction in the powdered coal and oil-burning installations. Both these fuels must have large combustion chambers, approximately one cubic foot to the horsepower to be developed, in the case of steam atomizing burners, and it is also essential that the bridge wall be moved sufficiently to the rear so that the intensely hot flame shall not strike it and melt it or burn holes through it.

Here again, the horizontal shelf laid on one of the lower rows and tubes and connecting the bridge wall with a cross baffle has its objections. Instead of allowing the heat generated to reach immediately the heating surface in the first pass, it reflects it back into the furnace with resulting temperatures which are disastrous to the furnace linings. Again, the concentration at the elbow where the horizontal baffle meets the vertical baffle, of the heat flowing from the back of the furnace which rises and flows along the horizontal baffle, of the radiant heat from the flame, and the uprising heat from the front of the furnace is too much for the tubes and they burn out at this point. Untold grief has been caused by this defect in design, and by the failure to get the combustion space large enough.

A glance at Fig. 5 will show how both these requirements have been met. The boiler had been converted from oil burners without materially increasing the furnace volume and an average of four burned tubes were removed every Sunday for several months. The furnace linings required frequent repairs, and the ratings obtained were unsatisfactory, and the economy expected was not fully realized. The floor level was then dropped, the bridge wall moved back and a 45 deg. baffle wall without any shelf was built and the furnace after 28 mo. continuous use has required only minor repairs, no tubes being renewed except the crooked ones left in when the change was made. The ratings and economy have been entirely satisfactory.

At another plant, the lower setting of the boiler made advisable the back shot type of burner. The first construction with a horizontal shelf resulted in the renewal of 12 tubes in the first 54 days' run, coupled with an inability to develop 100 per cent of builders' rating. The next boiler installed was equipped with the 45 deg. wall shown in Fig. 6, and after 57 days' run at 200 per cent of rating required renewal of no tubes and resulted in lower stack temperatures and higher CO_2. As this boiler will develop over 100,000 hp. more annually than its running mate, the advantage gained is evident.

There has been a growing realization of the value of the radiant heat in the furnace and every effort is now made to expose as much of the tubes in the first pass to its effect as possible. This the inclined baffle wall does.

The makers of underfeed type stokers are finding that the flat arch in the roof of the furnace is a serious factor in increasing the upkeep of the stokers. The reason is evident. When the stoker is driven to its capacity, the rush of air through the tuyeres keeps everything reasonably cool, but when the load goes off and the blower slows down, the horizontal shelf reflects the heat down on the fire and the heat sinks in; then the stoker man longs for an inclined wall that would let the heat go up where it belongs, that is into the heating surfaces of the boiler.

Another combustion trouble has been largely abated when it has not been entirely eliminated by the use of the inclined wall.

Many fuel beds produce a flying fusible ash caused by the high velocity of the gases picking up incandescent particles from the fire and hurling them against the comparatively cool tubes where they chill and stick, not only gradually redueing the space between the tubes, but by

their insulating properties cutting down the heating surface of the tubes affected.

The inclined wall opens the throat of the first pass so that the velocity of the gases is reduced and their tendency to pick up and carry away the incandescent particles is much lessened, and the particles actually lifted have time to burn before reaching the tubes. The area between the tubes which may be slagged over is largely increased so that the boiler may be kept longer on the line before the draft loss becomes too heavy. In addition, the throwing of a larger proportion of the heat-

sure to follow quickly. It may be that the fact that a method of constructing these walls so they are really gas tight and at the same time proof against anything but mechanical injury has a great deal to do with the results obtained, but it still remains true that all the logic is in favor of the tapered pass. Entirely new possibilities have been presented to designing engineers by the ability to put baffle walls where they should be located to suit the varying requirements of modern combustion instead of to suit mechanical construction and they have not been slow to avail themselves of these opportunities.

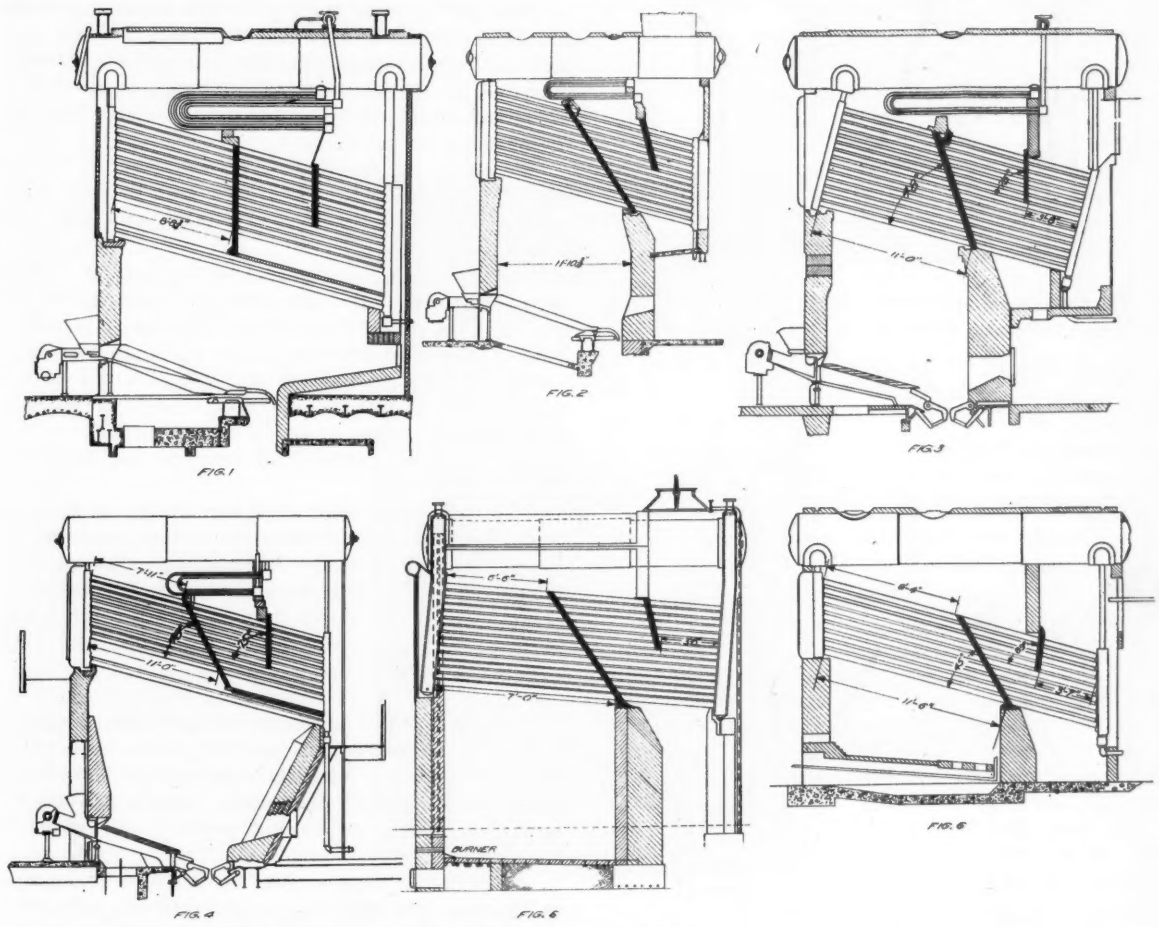


FIG. 1. THE BRIDGEWALL WAS CARRIED BACK UNTIL IT MERGED WITH THE REAR WALL
FIG. 2. FURTHER DEVELOPMENT RESULTED IN ABOLISHING THE LOWER PORTION OF REAR WALL
FIG. 3. THE FACE OF THE WALL WAS THEN SLOPED TO THE REAR
FIG. 4. FINALLY THIS RESULTED
FIG. 5. THIS DESIGN PROVIDES A LARGE COMBUSTION SPACE AND PREVENTS MUCH FURNACE TROUBLE
FIG. 6. BOILER EQUIPPED WITH A 45 DEG. BAFFLE WALL

ing surface into the furnace chamber lowers the furnace temperature so that the maintenance cost of the furnace linings is materially reduced (Fig. 7).

It is now generally conceded that the passes in the water-tube boiler should be tapered from the bottom of the first pass to the top of the third pass. One evidence of this is the fact that over 300,000 hp. of boilers have been changed from parallel pass to tapered pass by one baffle wall company alone in the last 2 yr., and so far as is known, none have been changed back. On the contrary, if one boiler in a plant is changed, the others are

One field just entered upon is the application of the high-velocity theory recently developed in connection with waste-heat boilers to radiant-heat boilers. According to this theory, gases of low-heating value must be speeded up so that a larger volume shall be brought in contact with each unit of heating surface in a given time. By building the front baffle with a long slope, making the front pass as large as possible, and the rear passes narrower than usual, the front end of the boiler is run as a radiant-heat, and the rear as a waste-heat boiler. In other words, full advantage is taken of every

bit of radiant heat available by exposing as much as possible of the lower tubes to its action.

The gases move slowly through the voluminous first pass with ample time to transfer their heat to the heating surfaces, the pass being proportioned so that as they cool and shrink in volume, the baffle wall closes in so as

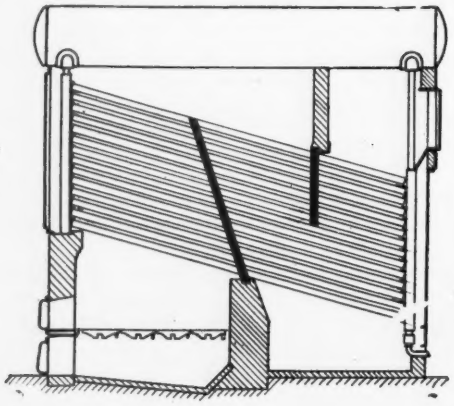


FIG. 7. RELATIVE GAS PASSAGE AREAS AND HEATING SURFACES IN BOILER FITTED WITH INCLINED BAFFLES

to compel them to fill the entire surface and reach the often neglected surface at the front of the top header. On making the turn at the top of the front pass and passing through the superheater, the speed is accelerated and the narrowing space increases the density of the gas and accelerates its movement so that the rear tubes are flooded

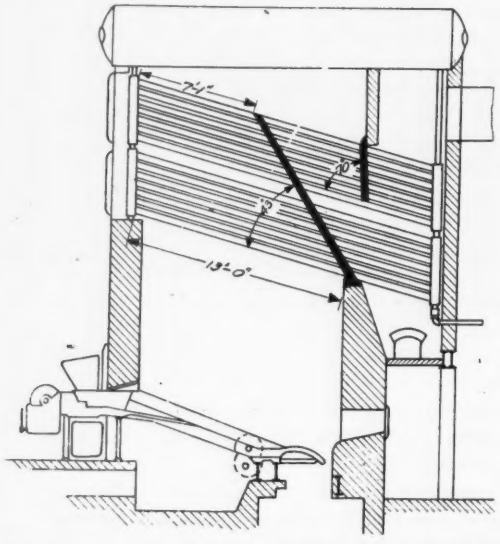


FIG. 8. WITH THIS BAFFLE-WALL ARRANGEMENT THE FRONT END OF THE BOILER IS RUN AS A RADIANT HEAT AND THE REAR END AS A WASTE HEAT BOILER

with a denser gas at a high velocity and the heat transfer is the maximum. (See Fig. 8.)

The apparent restriction at the bottom of the rear baffle is only apparent as the gases on making the turn have the advantage of parallel flow along the tubes instead of cross flow between the tubes and the space between the decks is also utilized to provide ample area.

The new baffle-wall construction has apparently attracted the attention of combustion engineers and baffles are being designed and successfully constructed which would have been thought revolutionary a few years ago.

Plan the Job

By J. S. Carpenter

A GREAT mathematician once said that if he were given 5 min. to solve a certain problem, he would spend 3 min. thinking how to do it. He felt that by that time he could get a good idea of the conditions and decide on the best method of attack. He was then prepared to go ahead, with the least possible waste of time, and get the job done. So prepared, he saved himself all the trouble of two or three "bum starts" and the fun of doing the job all over.

We can do the same! Take a good squint at the job, get all the tools handy, talk it over with the boys a bit, decide on the best "method of attack" and hop to it. You'll win!

In the Production Department they call it "analysis," but it means the same thing. It means that you think out HOW BEST to do the work before you do it. That is intelligent planning. The ability to plan intelligently is born of habitual analysis. The fellow who tries to take out the piston before he gets the cylinder cover off isn't of that kind. He has no care for the morrow and lets each unthinking, haphazard moment take care of itself.

If you habitually keep studying how best to do things before you do them, you will soon fall into a mighty fine rut that is real efficiency; much though that word has been abused. You will unconsciously work yourself into a better job. You won't have to take a brace of six-shooters to go and get a raise. The Boss isn't blind. PLAN THE JOB!

The Harvard Engineering School has adopted a new plan of instruction for the junior year of the Engineering course whereby students will hereafter be given an opportunity to combine classroom work with 6 mo. of active engineering practice and industrial training.

According to the new plan, which will be inaugurated in June and will apply to the instruction in mechanical, electrical, civil, sanitary, and municipal engineering, every student who wishes to take the industrial training work will spend half his time during his junior year working in industrial or engineering plants within easy reach of Cambridge. A schedule has been arranged which will enable these men to secure the full amount of regular classroom instruction and also to spend three separate periods of 2 mo. each in the industrial work. The schedule of work for the freshman, sophomore, and senior years will remain approximately what it is now, so that students in the Engineering School will fully retain during at least 3 yr. and also during part of the junior year, the advantages of life in the college surroundings which the school now affords.

The best reward is sense of worthy achievement.—Forbes Magazine.

WALTER DAMON

FROM FARMER'S BOY TO SUPERINTENDENT OF GENERATION BY WAY OF THE "HARD KNOCKS" ROUTE, ASSISTED BY AN UNFAILING LOYALTY AND A WINNING DISPOSITION. BY W. F. DANIELS

MOST mechanically minded men have two educations—that which is given them and that which is acquired; and usually the second kind is the more valuable. It is the solid, practical stuff that enables the engineer to work out his many and diversified problems and climb to his desired goal. That's just the way it was with Walter Damon.

Walter H Damon

At the age of eleven, a chap hasn't a world of confidence and courage—there is a lot that he doesn't know—but that is just when Walter began shifting for himself. He first worked for a thrifty old Massachusetts farmer from daylight until nightfall for just food and clothing. It was a hard, back-breaking job, but Walter stayed out in the hills for several years.

Then he found an opening in a wood-working and carpenter shop which paid him the munificent wage of $8 a month and board; and his working day was almost as long and laborious as on the farm. Two years later he came into Springfield, Mass., and began working for a contractor. Here he chauffeured a team of horses, helped on buildings, and served as an all 'round handy man.

About five years later, in 1891, Walter decided that he wanted to work in a power plant, and as fireman's helper he began wheeling ashes out of the boiler room of the United Electric Light Co. at Springfield. At that time the plant had only four 800-hp. boilers.

Now, all firemen's helpers usually do one of two things—they either quit or become full-fledged firemen. Walter stuck; but he didn't remain on the payroll very long as fireman. Just a few years, and they wrote "Assistant Engineer" after his name, and then "Chief Engineer." Step by step Walter's unfailing loyalty and ever-increasing ability carried him along to the more important positions. He acquired a keen insight of the principles which govern good power plant operation, always had the full support of his men, and never sidestepped the hard or unpleasant duties.

Today he is the "Superintendent of Generation" for the same plant in which he started 29 yr. ago as fireman, only it has been remodeled and enlarged until the present capacity is around 35,000 kw., made up of units ranging in size from 1000 to 25,000 kv.a. The boiler house, instead of having a rating of 800 hp., contains twelve 700 and eight 400-hp. steam generating units.

He also is in charge of the operation of other generating stations—water power plants—located at Indian Orchard and Berchim Bend, which supply energy to the same system served by the Springfield steam plant.

Walter Damon's fine works and friendly influences have become nation-wide. He is an untiring worker for the National Association of Stationary Engineers, and is one of its past national presidents. He has also given valuable service as a member of the American Society of Mechanical Engineers, and National Electric Light Association, the Universal Craftsman Council of Engineers, and the Western Massachusetts Engineering Society. He is also an active member of a number of fraternal organizations.

Here's to Walter Damon, the finest boss I know. He is never too busy to greet an acquaintance, has never gone too high to put on his overalls and work with the rest occasionally, and deserves every success that may come to him.

THE FIRST spring meeting of the Engineering Section, National Safety Council, was held in the Engineering Societies Building, New York City, on April 27. The relation between safety and engineering and the engineer's place in the modern industrial world constituted the motif of the entire program, a number of the papers read being presented by engineers prominent in accident prevention work and in engineering education.

"DO NOT travel over beaten paths if you seek the road to success."

How Much Lubricant Does an Engine Need?

By W. F. Schaphorst

HOW DO you know whether or not you are feeding your engine bearings sufficient oil? In what way are you doing the oiling? Are you giving them a few drops at a time, every once in a while, and trusting to luck that there will be no hot box, and that the friction horsepower will be maintained at approximately the most economically low point? Have you looked into the lubricating problem with much thoroughness?

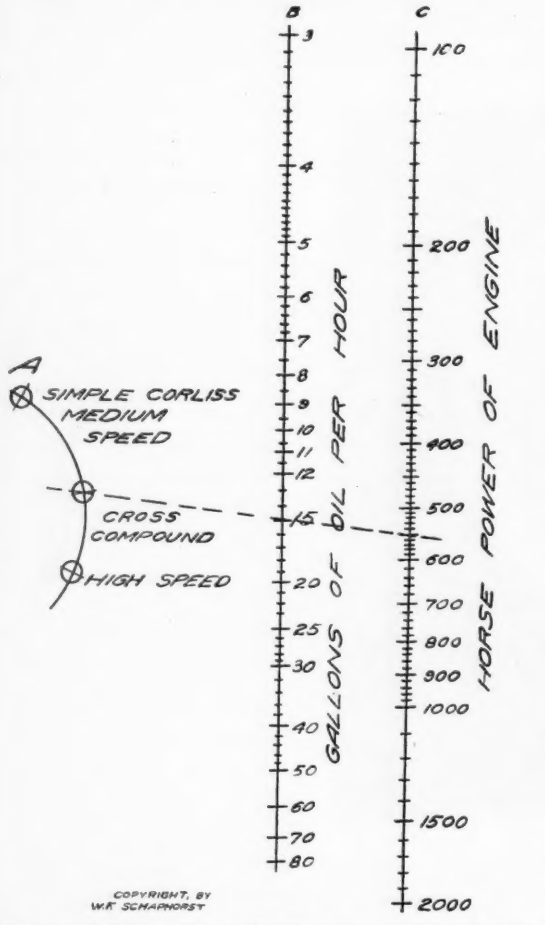


CHART FOR DETERMINING AMOUNT OF OIL NEEDED BY AN ENGINE

The foregoing questions are asked so bluntly because the chances are ten to one that you have been satisfied with the old method of lubricating. Most owners, superintendents, managers and engineers are. You haven't been made to feel that a change in your system is worth while. Much experimenting has been done on this important subject in recent years, and as a result automatic lubricating and filtering systems have been developed that are marvels of thoroughness in that they keep all bearings supplied with copious streams of oil at all times, reducing the necessity of keeping the bearings screwed up tight all the time. Looseness is no longer so much of a crime. The oil keeps the "cracks" filled up and the shaft and bearings operate on a thick film of oil without coming into actual metallic contact. Vibrations and shocks are muffled. The oiler doesn't have to climb around on a ladder and get into dangerous places. In fact, there is no oiler whatsoever; he is eliminated. Oil isn't constantly spilled on the floor because it is kept within pipes or in tanks where it cannot spatter. If any dirt or grit gets into the bearings it is washed out by the rapid flow of oil, carried along with the oil, and finally filtered out. Money is saved because labor is dispensed with; repairs become less frequent, because of the power saving the yearly coal bill is lessened; and, due to the fact that the oil is used, filtered, used again, and so on, the yearly cost of oil is reduced to the very minimum.

The quality of the oil does not appreciably change. Since one bearing may need considerably more oil than another, it is a simple matter constantly to feed the right amount to any given bearing, large or small, high-speed or low-speed.

So many experiments have been performed upon engines and so much experience has been had with lubricating problems that it is pretty well known by this time how much oil any engine of a given size or speed demands for proper and thorough lubrication.

Based upon tables that are the outgrowth of innumerable tests of this sort, the writer has therefore developed a "handy chart" which tells at a glance the amount of oil needed for any ordinary Corliss engine of medium speed, any ordinary cross compound engine, or any ordinary high-speed engine.

Simply lay a straightedge across the chart joining the kind of engine (curve marked "A") with the horsepower of the engine (column "C") and the intersection with column "B" immediately gives the number of gallons of oil needed per hour.

For example: How many gallons of oil are needed per hour by a 550-hp. cross-compound engine? Connect the point corresponding with "cross compound" (curve marked "A") with the 550 (column "C") and the intersection with column "B" shows the answer as being 15 gal. per hour. The dotted line drawn across the chart shows how it is done.

A high-speed engine of the same power will require about 17 gal. per hour, whereas a simple Corliss engine will need only 13 gal. per hour. The range of the chart is great enough to take care of most engines up to 2000-hp. Thus a 2000-hp. high-speed engine would require a bit more than 50 gal. of oil per hour.

She had been to the power house, taking along her girl friends. Papa was the superintendent, and in showing the girls around, remarked: "These two big fellows are running in parallel."

When daughter met him alone that evening, she said: "Daddy, I was terribly humiliated today and you caused it."

"Why, dear, what did I do?"

"You told us those machines were running in parallel, and two of those girls are students in geometry, and they said that they positively know you were wrong: that the machines were running at right angles. They even demonstrated that by showing their positions alongside. Daddy, please review your geometry."

The Air Lift Pump

NOTES ON ITS DESIGN AND OPERATION. BY CHARLES C. PHELPS

THE HEAD of water corresponding to the submergence (distance from level of the water in the well down to the point at which the air enters the discharge pipe) of an air lift pump must be slightly greater than the head of mixed air and water in the discharge pipe (distance from point of discharge down to point at which air enters the discharge pipe, that is lift plus submergence). This fact furnishes the clue for calculating the pressure at which the compressed air must be supplied. A higher air pressure will be required for starting because the level of the water in the well recedes after starting; in other words, the starting submergence is always greater than the running submergence. One foot head of water is equivalent to 0.434 lb. per sq. in. pressure. Therefore, to find the starting air pressure multiply the starting submergence by 0.434. For example, if the water level in the well before pumping is 60 ft. below the ground level and the air foot piece is down 300 ft., then the starting pressure would be $(300 - 60) \times 0.434 = 104$ lb. per sq. in.

In the same example, let us assume that the water recedes 40 ft. while pumping. The water level would then be 100 ft. below the ground level and the running submergence would be 200 ft. The air pressure required to force the air out of the air pipe against the pressure of the 200-ft. head of water would be equal to $200 \times 0.434 = 87$ lb. per sq. in. This pressure would not, however, be sufficient to operate the pump because it does not provide for pipe friction. It would therefore be necessary to increase the pressure a little, the exact amount of which could be determined from tables giving loss of head due to pipe friction. Such tables are to be found in several handbooks.

The subject of pipe friction brings us to an interesting problem that enters into the design of air lift systems, especially deep ones; namely, how to keep pipe friction as well as air slippage at the lowest practicable limits. One way to reduce pipe friction is to discharge the water at comparatively slow speeds. Slow discharge speed, however, results in bubbles of air slipping up through the water while the column is ascending. There is always some slippage due to the buoyancy of the air bubbles, but this slippage is small when the velocity of the water is great because the water is discharged before the small bubbles have had time to merge into large bubbles and slip to any great extent. The problem in designing an air lift pump that will be efficient, is to strike a compromise between loss due to pipe friction and loss due to slippage so that the overall loss will be the least possible. As the column of aerated water ascends, its velocity increases because the air bubbles become larger as they ascend, due to the decreasing pressure and this increasing volume can be taken care of in a pipe of uniform diameter, only by increasing velocity. Sometimes the velocity has been kept more nearly uniform by enlarging the diameter of the discharge pipe in one or more sections towards the upper end.

The air pipe may be run down the well either inside of the discharge pipe or outside of it. It is often simpler to run it inside of the discharge pipe but that type of construction has the disadvantage that more pipe surface is exposed to the water and the friction of the water against the two pipes becomes greater. The deeper the well the more serious the pipe friction becomes, and the more important it becomes to keep pipe friction to a minimum. Largely for this reason, the percentage of submergence is reduced as the depth of the well increases.

AIR FOOT PIECES

IT IS QUITE apparent that small size of air bubbles is favorable to high efficiency. Many types of foot pieces

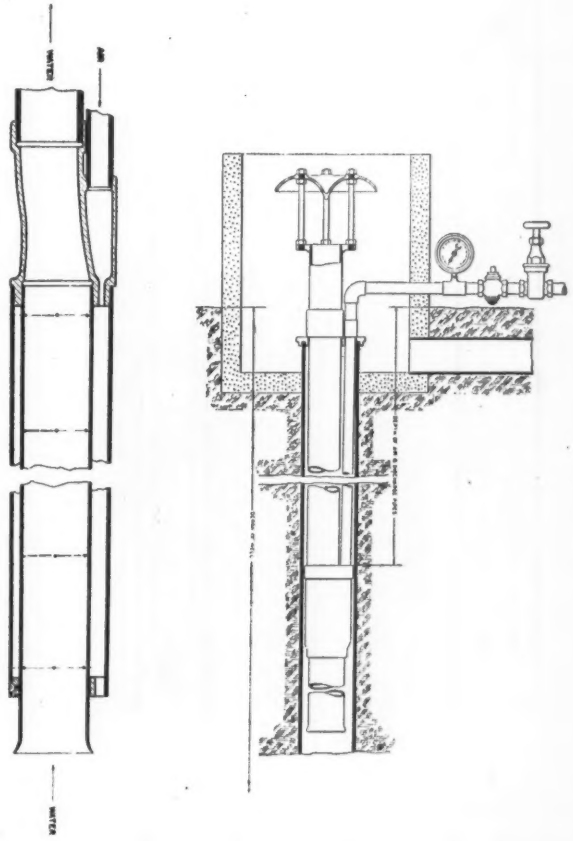


FIG. 1 FIG. 2

FIG. 1. FOOT PIECE FOR OUTSIDE AIR PIPE SYSTEM
FIG. 2. FOOT PIECE FOR CENTRAL AIR PIPE SYSTEM

have been designed for the purpose of introducing the air into the water in small bubbles. The bubbles are often so small that even at the discharge they resemble effervescence of mineral water. This condition is spoken of as a "champagne effect" and is considered highly desirable. Figure 1 illustrates a type of footpiece used with an outside air pipe type of air lift system, such as Fig. 2. Figure 3 is a footpiece for an inside or central air pipe system such as Fig. 4.

In both types of footpieces the air issues through

small holes in the brass tube forming the principal part of the footpiece. The greater the air pressure the less will the water back up into the footpiece and the more air will escape because more of the small holes will be uncovered. The air is regulated at the beginning so that the number of holes will be uncovered that will give the best result. Thereafter the footpiece will act somewhat as a regulator because the air will uncover the necessary number of holes automatically, thus compensating for momentary lightening or increase in weight of the discharge column due to coalescence of air bubbles or any other cause.

FIG. 3

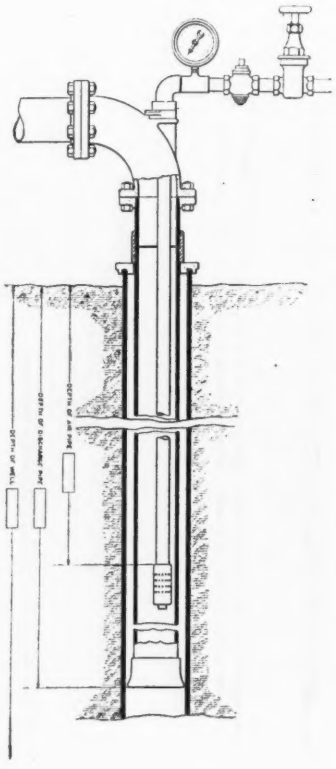


FIG. 4

FIG. 3. AIR LIFT SYSTEM WITH OUTSIDE AIR PIPE
FIG. 4. AIR LIFT SYSTEM WITH CENTRAL AIR PIPE

Both of these footpieces also provide for the discharge of any scale or dirt that might enter them from the air or discharge line. Such particles of foreign matter would tend to fall out through the bottom instead of entering and clogging the small openings. Figure 2 illustrates the "umbrella" type of discharge, which is very convenient when the air lift discharges into a reservoir placed directly above the well. Figure 4 shows a pipe discharge piece such as is commonly employed when the air lift discharges into a vessel placed to one side of the well.

Due to what was evidently a typographical error in the article on the Air Lift by C. C. Herman in the March 15 issue of Power Plant Engineering, the formula for calculating the air volume required to raise one gallon of water was given incorrectly as:

$$Va = \frac{h}{c \log. \frac{H - 34}{34}}$$

The formula should be expressed as follows:

$$Va = \frac{h}{c \log. \frac{H + 34}{34}}$$

in which Va = free air (actual), in cubic feet, required to raise one gallon of water

h = total lift in feet

H = running submergence in feet

c = a constant varying for different lifts (The values of the constant were given in the March 15 issue).

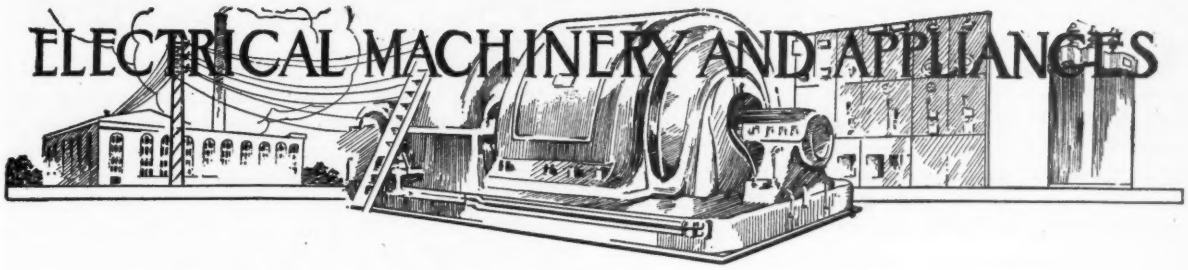
The question that naturally arises in the reader's mind at this point is whether this formula applies to all liquids. It applies only to liquids having the same specific gravity and other physical properties as water. For liquids having other specific gravities the approximate air consumption may be found easily if the liquid is one that flows readily. In the formula given, the figure 34 represents the pressure of the atmosphere expressed in feet of a water column corresponding to 14.7 lb. per square inch. The pressure of the air at the bottom of the discharge pipe, expressed in water head, must be approximately H + 34 ft., that is the pressure of the water plus the pressure of the air. Therefore the fraction $\frac{H + 34}{34}$ represents the ratio of expansion of the air in ascending from the bottom to the top of the well. If a liquid of different specific gravity than water is employed, it is obvious that the figure 34 cannot be employed, but for it we must substitute the head of that particular liquid corresponding to atmospheric pressure. This may be found by dividing 34 by the specific gravity of the liquid. Thus for liquids lighter or heavier than water it would be necessary to find the common logarithm of $\frac{H + (34 \div \text{Sp. G.})}{34 \div \text{Sp. G.}}$

Likewise the constant c should be divided by the specific gravity or, what amounts to the same thing, the numerator (h) may be multiplied by the specific gravity, thus:

$$Va = \frac{h \times (\text{Sp. G.})}{c \log. \frac{H + (34 \div \text{Sp. G.})}{(34 \div \text{Sp. G.})}}$$

Sp. G. represents the specific gravity, that of water being 1.

FIRE LOSSES in the United States and Canada in 1918 were $317,014,385, most of them due to carelessness. Fire losses and the cost of fire prevention in the United States amount annually to $450,000,000.



A Study of Dynamo Electric Machinery---XIV

CONSTANT-CURRENT TRANSFORMERS; PHASE TRANSFORMATIONS AND CONNECTIONS. BY OTTOMAR H. HENSCHEL

REGULATION of transformers is calculated in a way similar to that of generators. It is equal to the difference between full load and no load secondary voltage expressed as a per cent of full-load secondary voltage. Thus, a given transformer connected to a constant-voltage primary line has a full-load voltage of 109 and a no-load voltage of 112; its regulation is then equal to the quotient obtained by dividing the difference between 109 and 112, or 3, by 109. This is equal to 0.027, which, times 100, is 2.7 per cent, the efficiency of the transformer.

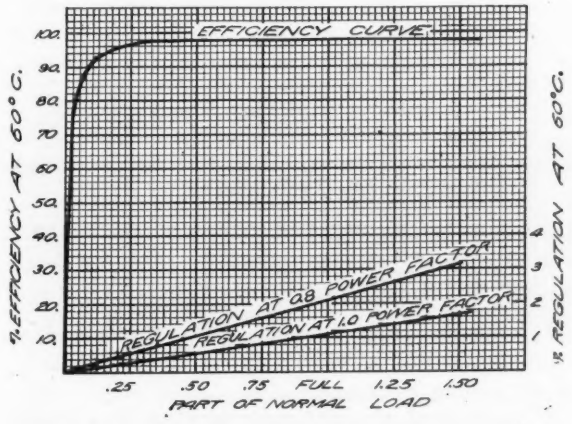

EFFICIENCY CURVE
% EFFICIENCY AT 60° C.
% REGULATION AT 60°C.
REGULATION AT .08 POWER FACTOR
REGULATION AT 1.0 POWER FACTOR
.25 .50 .75 FULL 1.25 1.50
PART OF NORMAL LOAD

FIG. 95. TYPICAL TRANSFORMER EFFICIENCY AND REGULATION CURVE

Resistance of the coil windings and magnetic leakage are the two factors responsible for the change in secondary voltage with change of load. With a non-inductive load, voltage change is due almost entirely to coil resistance, while, where the transformer is supplying current to a highly inductive load, decrease in secondary voltage is due to magnetic leakage, which also causes an increase in terminal voltage with increase of load where the secondary of a transformer feeds a circuit of high capacity.

Dividing the output of a transformer by its input (both in watts) and multiplying the quotient thus obtained by 100 will give as a result the per cent efficiency. At light loads, as in the case of any machine, the efficiency of the transformer is comparatively low; above 25 per cent of its rated capacity, however, the efficiency is high, in many instances in the case of large size units operating at full load exceeding 99 per cent. A typical transformer efficiency curve is shown in Fig. 95.

Transformers primarily employed to furnish light and power are ordinarily termed distribution transformers, and, due to the fact that they supply energy but a comparatively short time during each 24 hr., their all-day efficiency is as a rule quite low. Let us assume that a 15-kv.a. transformer having an iron or core loss

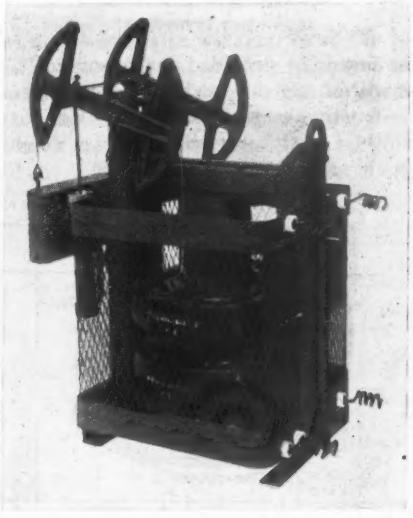


FIG. 96. TRANSFORMER OF THE CONSTANT-CURRENT TYPE

of 500 w. and a copper loss of 500 w. when fully loaded, works at full capacity (and unity power factor) but 2 hr. each day and is without load the remaining 22 hr. The core loss remains constant, so that this for 24 hr. amounts to 24 times 500, or 12,000 w., while the copper loss is equal to 2 times 500, or 1000 w., thus indicating that when the transformer is working at rated capacity, that is, is delivering 15,000 w., it is being supplied with $(2 \times 500)+(2 \times 500)+(2 \times 15{,}000)$, or 32,000 w.-hr. It is, however, receiving, during the remaining 22 hr., 22 times 500 w., or 11,000 w.-hr. to compensate for the continuous core loss. The total energy delivered to the transformer during the day is then equal to 32,000 plus 11,000 w.-hr., or 43,000 w.-hr. The total input is then 43,000 w.-hr., the output 30,000 w.-hr., so that the all-day

efficiency is equal to 30,000 divided by 43,000, or 0.69, or 69 per cent.

Let us further assume that this transformer, instead of being operated but 2 hr., is made to supply full rated capacity for 10 hr., and make a comparison of the efficiencies. The core or iron loss remains at 24 times 500, or 12,000 w.-hr., the copper loss is equal to 10 times 500, or 5000 w.-hr., and the output is 150,000 w.-hr., thus making a total of 12,000 plus 5000 plus 150,000 w.-hr.,

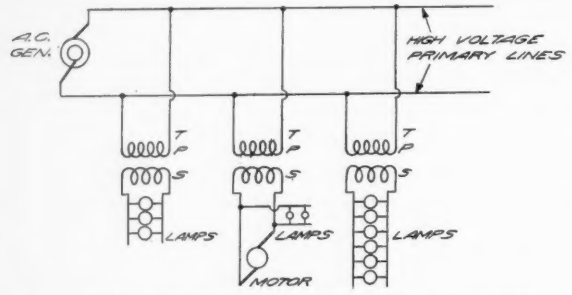


FIG. 97. METHOD OF CONNECTING SINGLE-PHASE TRANSFORMERS

or 167,000 w.-hr. of energy delivered to the transformer. Its output is 150,000 w.-hr., which, divided by 167,000, is equal to 0.89, or an all-day efficiency of 89 per cent.

Cooling Systems

Unless means be provided for removing it, the heat developed within the cores and windings of transformers will be destructive to the insulation. Various schemes are employed for this purpose, among which are the following:

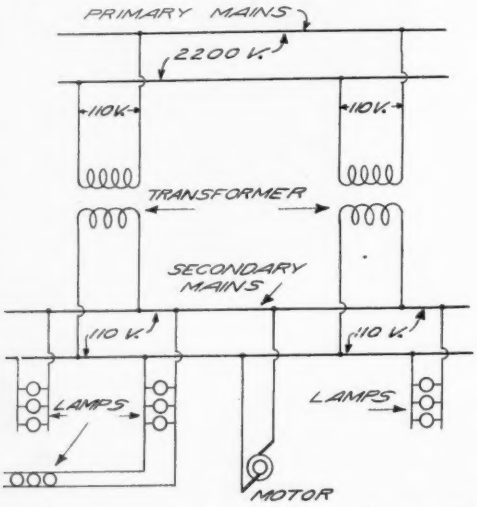


FIG. 98. DIAGRAM OF CONNECTION OF "BANKED" TRANSFORMERS

(1) Natural convection of air and radiation.

(2) Forced convection of air.

(3) Natural convection and radiation with two fluids.

(4) Combination of natural convection of a fluid medium with forced convection of cooling air.

(5) Natural convection of an insulating fluid cooled artificially by another fluid.

(6) Forced convection of an insulating fluid cooled in any convenient way.

For small distributing transformers, that is, for units up to 25 kv.a. rated capacity, and for instrument and switchboard transformers the first-mentioned scheme is the one most generally employed, while the forced convection of air method, or, in other words, the air-blast method, is the one utilized on transformers having rated capacities up to 5000 kv.a. and operating at voltages less than 35,000 v. It is common practice to use about 150 cu. ft. of air per minute per kilowatt of loss, the air being forced through the transformer by a blower at a pressure of from 0.5 to 1.5 oz. per square inch.

In the third method, applicable to transformers with rated capacities up to 4500 kv.a., the windings are cooled both by natural convection of air and oil circulating around and between the coils and the cores. The combination of natural convection of a fluid medium with forced convection of cooling air is a scheme not used extensively in this country, and therefore not calling forth any discussion. The other two arrangements consist of insulating the windings with oil and cooling by forced circulation of water and by forced circulation of the cooling medium.

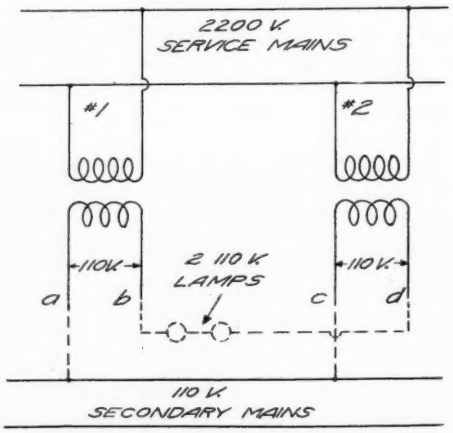


FIG. 99. CONNECTIONS FOR TRANSFORMER POLARITY TEST

The required physical characteristics of a cooling fluid may be enumerated as follows: It must be a good insulator and must possess good thermal conductivity and high specific heat. Its co-efficient of expansion should be high and its velocity as low as possible.

Constant-Current Transformers

These are used primarily in connection with series street lighting systems or wherever a constant secondary current at variable voltage is desired. An elementary form of such a transformer is shown in Fig. 96. Essentially, it consists of a laminated iron structure or framework carrying one or more stationary coils, the primaries, and one or more movable secondary coils, which, as shown, are balanced against gravity by a counterweight connected to the coil by a strap or cable passing over a sheave. A dashpot is provided to prevent sudden oscillations of the coil.

With constant load, that is, with fixed secondary external circuit resistance, the movable coil assumes a given position. However, for some reason or other,

should the resistance of the external circuit be decreased, greater flow of current will result, which causes an increase of repulsion between the two coils, and, as a consequence, the upper coil moves upward and the increase of leakage flux lessens the useful flux through the secondary coil. This reduces the induced voltage in the secondary coil, thus counteracting the tendency of the current to increase. Where the external circuit resistance increases, the opposite action takes place. The flow of current is cut down, with the result that, due to the decreased repulsion between the two coils, the upper coil moves downward. The leakage flux is thereby decreased, the useful flux increased and more current caused to flow through the external circuit.

Frequently the primary coil is made movable and the secondary coil fixed. Sometimes both coils are made movable, in which case they may be made to counterbalance one another by the employment of suitable mechanism and counterweights.

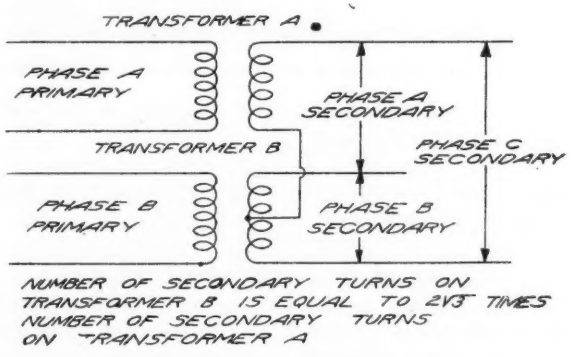

TRANSFORMER A
PHASE A PRIMARY
PHASE A SECONDARY
TRANSFORMER B
PHASE C SECONDARY
PHASE B PRIMARY
PHASE B SECONDARY
NUMBER OF SECONDARY TURNS ON TRANSFORMER B IS EQUAL TO 2√3 TIMES NUMBER OF SECONDARY TURNS ON TRANSFORMER A

FIG. 100. SCOTT SCHEME OF CONNECTION FOR TWO-PHASE TO THREE-PHASE TRANSFORMATION

Where the capacity of the transformer does not exceed 100 kv.a., air cooling is used; however, where the capacity exceeds this figure, the transformer is immersed in oil, and, in some instances, water cooled.

Connections

In a single-phase constant-voltage system, the individual transformers are connected in parallel across the two main lines, in the manner indicated in Fig. 97. Current is supplied by the alternating-current generator at high voltage to the primaries P of the transformers T, which step-down the voltage to a value dependent upon the ratio of primary to secondary winding turns; secondary windings S then deliver the current at the reduced voltage to the consuming devices, which may be in the form of lamps, motors, etc. Frequently, and especially in districts where a heavy demand for current exists, not only the primary windings are connected in parallel, but also the secondary windings. This scheme of connections, often termed "banking," is illustrated in Fig. 98, and, when employed, care must be exercised to see that the ratio of primary turns to secondary turns is the same in each unit and that the voltage drop from no load to full load is the same, both in magnitude and in phase, for all of the transformers so connected. With unequal ratios of transformers, the secondary voltages will be unequal, and, as a result, the unit or units having the higher secondary voltages will carry the heavier loads.

Before connecting two or more transformers in parallel, it is advisable first to conduct a polarity test. To do this, refer to Fig. 99, showing two single-phase transformers with primaries connected in parallel across

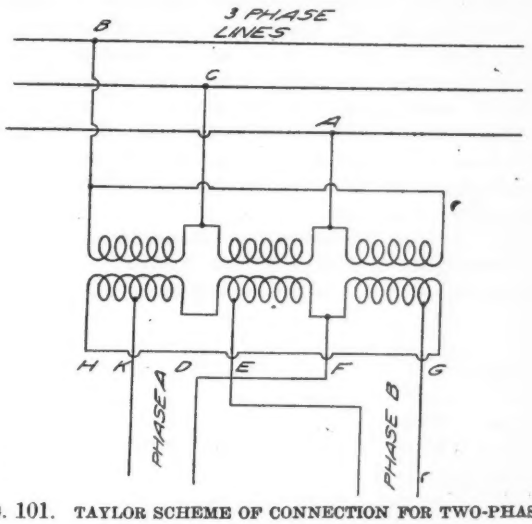


FIG. 101. TAYLOR SCHEME OF CONNECTION FOR TWO-PHASE TO THREE-PHASE TRANSFORMATION

the service mains and with secondaries of the two units, Nos. 1 and 2, lettered a, b, c and d. Connect secondary leads a and c to either one of the secondary mains, and, between terminals b and d connect two 11-v. lamps (lamps of such voltage rating used when secondary voltage of each transformer is 110 v.). If the lamps do not

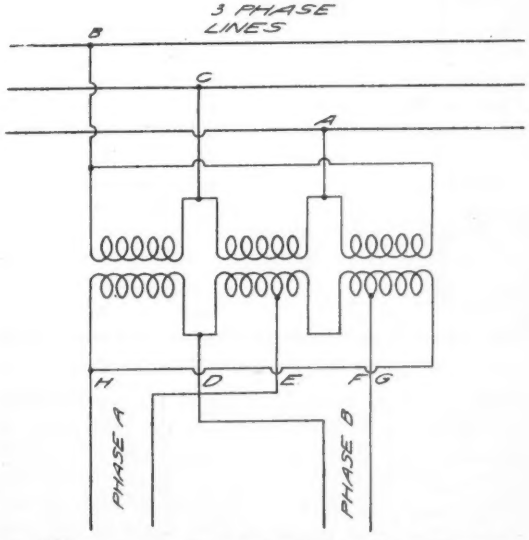


FIG. 102. A PRACTICAL AND SERVICEABLE SCHEME OF CONNECTIONS FOR TWO-PHASE TO THREE-PHASE TRANSFORMATION

light, terminals a and c are to remain as connected, and b and d made to tie in with the other secondary main; however, should the lamp light, secondary leads a and d must be connected to one secondary main and b and c to the other.

Two- to Three-Phase Transformations

Prior to the general use of three-phase alternating-current generators, but while two-phase machines were being generally introduced, the economy of three-phase transmission was appreciated, and, while many of the systems constructed were designed for two-phase work, they could not, without the use of expensive machinery, be then used for the handling of three-phase currents. Scott, however, devised a scheme of transformer connections whereby the current supplied by a two-phase machine could readily be transformed to three-phase, and, as a consequence, even today many of the early two-phase generators are used to serve three-phase systems, frequently being operated in parallel with other three-phase machines.

In the Scott transformer, as shown by the diagram of connections of Fig. 100, two similar primary coils are connected to the two-phase supply mains, while one

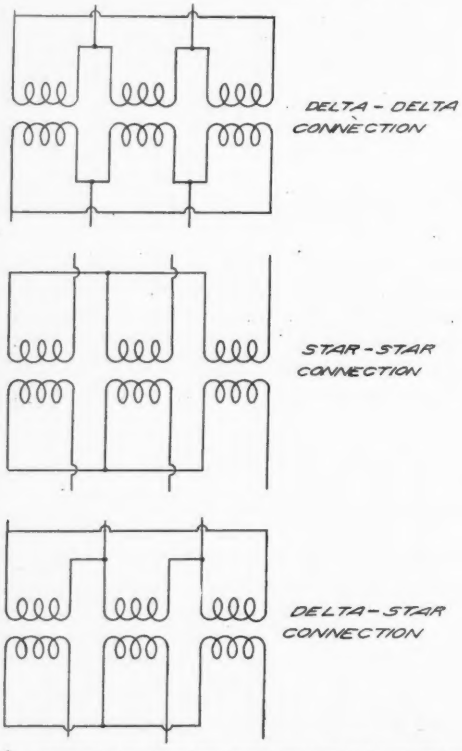


FIG. 103. TYPICAL STANDARD TWO-PHASE TO THREE-PHASE TRANSFORMER CONNECTIONS

leg of the secondary winding of one of the transformers ties in with a tap brought out from the mid point of the secondary coil of the other transformer. In order, however, to provide a like voltage across any two of the secondary mains, the number of turns of wire on the secondary winding of transformer A must be equal to $\sqrt{3}$ times the number of turns on each half of the secondary of the other transformer or the number of secondary turns on unit A is equal to $2\sqrt{3}$ times the total number of secondary turns on transformer B.

The loss of one of the units such as used in the Scott scheme of connections would result in complete interruption to service and where this, and the necessity of keeping a spare unit on hand is to be avoided, it is frequently desirable to use three transformers employing the so-called Taylor connection, indicated in Fig. 101. Another scheme as practicable and serviceable as that of Taylor is the one shown in Fig. 102.

Figure 103 illustrates a few typical standard two-phase to three-phase transformer connections.

Questions and Problems for Review

What is meant by the "all-day" efficiency of a transformer?

2. Mention four different methods of cooling transformers.

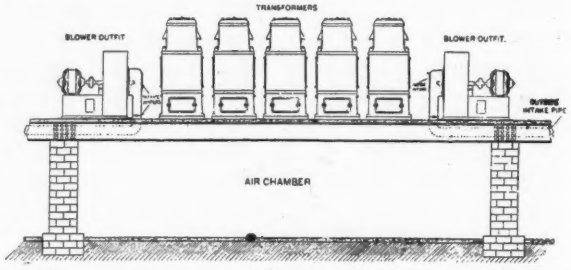


FIG. 104. METHOD OF INSTALLING AIR BLAST TRANSFORMERS

3. Explain the principle of operation of the constant-current transformer.

4. By means of a diagram, show how, with two single-phase transformers, it is possible to change from two-phase to three-phase, and vice versa.

Causes of Ring Fire and Flashing

"Ring Fire," says O. P. Forster in a recent issue of the Electrical Record, is the designation which has been given to that kind of sparking where rings of "fire" (electric arcs) embrace the circumference of the commutator, wholly or partially encircling it. Ring fire is of two classes: (1) Ordinary ring fire. This is of a reddish tint and it may exist, to a limited extent, on all commutators. (2) Armature-defect ring fire. This is of a bluish-green color and is more intense than that of the ordinary class.

Ring fire is originated ordinarily by minute arcs which form between adjacent commutator bars. Conducting materials which may lodge between the bars, in or on the surface of the mica insulation, aggravate the condition, and the current passing between the bars through these conducting paths renders the particles incandescent. Fine carbon, ground from the brushes by the normal operation of the machine, or particles of copper from a newly turned commutator, are the most prolific producers of this condition. Secondary sources are the oil, paraffin and commutator compounds which are sometimes used and into which particles of conducting material may lodge.

Undercut commutators, particularly those rotating at low peripheral speeds, are particularly subject to ring fire. The reason is that oils, greases and conducting materials can, on account of the undercutting, lodge readily between segments. Hence the commutator slots of slow-speed machines should be cleaned frequently with a stiff brush. High-speed commutators will not ordinarily require such treatment, because with them the centrifugal force which is developed is usually sufficient to prevent the retention of the dirt in the slots.

Generator Ventilation

A Review of the Development of Forced Air Ventilation for Cooling Large Machines. By Geo. Monson

MANY ARTICLES have been written on the necessity of ventilating turbine generators to remove the heat and to obtain increased output. It may, therefore, be of interest to review the progress that has taken place in the ventilation feature of these generators.

One of the first commercial machines designed was a two-stage 500-kw. four-pole 1800-r.p.m. unit. The generator was patterned in general after the then prevailing waterwheel and engine-driven types, having salient pole construction. The rotor body, with the field poles, was built of laminations riveted together in sections and forced on the shaft. This rotor had sufficient blower action to ventilate the generator in the following manner:

Air was drawn from the room through the top and the bottom of the generator into spaces between the poles, and then expelled directly into the room through the armature ducts and apertures cored in the frame for that purpose.

Several other units of different capacities were designed. Four-pole generators with a speed of 1800 r.p.m. up to 14-pole machines at 514 r.p.m. followed similar lines of construction and ventilation.

As the rotative speeds and capacities increased, the number of generator poles was correspondingly reduced and changes in the generator design were made to meet the new requirements of stresses, ventilation, etc. The principal departure was the inauguration of the cylindrical type of rotor having two or more field coils per pole. The rotor construction varied; some had laminated disk bodies with radial slots for receiving the field coils and others had parallel slots.

In generators of larger capacities than 5000 kw., laminated poles were dovetailed into steel plates, which were shrunk on fluted cast-steel spiders, and these in turn were mounted on the shaft.

At first, the air was drawn in at both the top and the bottom of the generator by the action of the rotor spider and forced out through the rotor and stator ducts. Part of the ventilating air also passed through the end windings and then through apertures in the frame to the room. On later machines, the ventilating apertures in the stator frames were eliminated, the air being taken in at the top of the generator and expelled to the room through openings in the generator base. The ventilation for this type of generator was easily accomplished; in fact, in many cases more air passed through the generator than was needed for good economy, hence baffle plates were inserted to reduce the quantity of air and thereby the windage losses.

Use of Hoods

It was found that in some stations the heated generator air exhausted from the base openings did not mix freely with the station air, but instead moved up along the stator frame and returned to the air inlet opening at the top of the generator, thereby causing undue heating in the generator. To prevent this a hood made either of steel plates or cast-iron was placed over the air intake shield. This hood had an opening which could be placed in any direction, for example, could be turned toward the station windows, which were kept open when the temperature inside the building was high. By this arrangement the air intake was further removed from the rising column of heated air, and cooler air was drawn into the generator. This hood served its purpose well on those machines.

Up to that time air had been taken from and discharged into the engine room. The power stations had been originally laid out and built for a certain kilowatt output with a given number of units, but this output was soon outgrown and increased capacities were required. The simplest and cheapest scheme was to replace existing units with new units of increased capacity. In some cases, due to the substitution of new units, the amount of power was several times that originally contemplated. The increased quantity of heated air from the generators could not be removed from the engine room by the old method. Therefore, in order to keep the temperature of the generator within safe limits, and to secure a more comfortable room temperature, it became necessary to install ducts through which cool air could be drawn from outside the station building to the generator, and thence to the discharge outlet, also located outside.

Air Washers

It has always been more or less dangerous to allow dirt to accumulate on the windings, since it clogs the air passage and introduces a heat insulating material on the surface exposed to the air, thereby causing excessive heating. Yet it has been difficult to prevent such accumulation. Although only a small percentage of dirt carried by the ventilating air may be deposited in the machine, the quantity of air passed through the machine is large and therefore the amount of dirt deposited is considerable. Some conception of the magitude of the quantities involved may be had from the fact that a 30,000-kw. machine requires approximately 6,000,000 lb. (81,000,000 cu. ft.) of ventilating air to pass through it during 20 hr. of operation. The rapid deposit of dirt under such conditions makes frequent cleaning necessary. In order to reduce the frequency of cleaning, which is a slow, expensive process requiring the dismantling of the machine, air washers were installed in the air intake duct. In addition to removing a large percentage of the dirt, these washers also serve the purpose of cooling the air, thus permitting higher generator output, especially during hot weather. The problem was thus partially solved.

First Use of Fans

The construction used in some of the earlier vertical alternators caused air pockets to be formed around the top and bottom ends of the windings, beyond the armature core. These produced eddies which prevented the proper flow of air. To overcome this difficulty a straight bladed fan was mounted on the top of the rotor for forcing part of the incoming cool air through, and

also around, the top end windings, thus overcoming the eddies. This fan directed the air downward between the stator core and frame to the outlet apertures in the base. In later designs, most of the generators had fans mounted also on the bottom part of the rotor.

It was recommended from the start that station air ducts be introduced, and that these be furnished with dampers for regulating the quantity of air. Later, doors were made in the ducts inside the station so that all the air, or part of it, could be taken from the room, or from outside the building, whichever was desired. Similar dampers were placed in the exhaust ducts, and in case of fire in the generator these dampers could be closed, thus impeding the progress of the fire.

Latest Construction of Generator

Turbine rotative speeds have now reached a maximum of 1500 r.p.m. for 35,000 kw., 25 cycles; 1800 r.p.m. for 30,000 kw.; and 3600 r.p.m. for 6000 kw., 60 cycles. The limit of output capacity with respect to speed is dependent upon the rotor stresses and the relation of the critical speed of vibration to the normal speed. To make such generators possible, the solid forged rotor construction was adopted, and has proved satisfactory. With this construction, the ventilation became a still more difficult problem.

For ventilating some of the first of these generators separate blower outfits were used. In some cases blowers were mounted on the end of the rotor shaft; but this practice was later abandoned and since that time it has been standard practice to mount fans on each end of the rotor body. The fans force the air at both ends, around and through the end windings into the air gap, and from there along the rotor body, and out through the armature ducts and frame as already explained.

Double Air Flow System

With the ever-increasing capacity of units, it became necessary on account of stresses to build the larger machines with a relatively small diameter and a great axial length. With the air pressure available, the air gap in such machines did not afford adequate space for the passage of the large quantity of ventilating air required. A new departure in ventilation was therefore advised.

Double-bladed fans were provided on each end of the rotor. Part of the air passes into the air gap in accordance with standard practice and part flows through tubes arranged outside the armature core leading to a central air pressure chamber where it passes through a number of armature core ducts radially inward toward the rotor and then axially along the air gap and out through the armature ducts, in the usual manner. By this arrangement it was possible to introduce air into the gap at four places and thereby force the necessary amount of air through the generator.

It seemed logical for power stations to use the exhausted generator air under the boilers for heat conservation. Ducts were therefore installed for the purpose, but this arrangement did not prove to be as successful as anticipated. During cold weather considerable condensation was caused in the engine room by air having high humidity coming in contact with the cold ceiling. Under unusually severe conditions fog would be present in the room, causing dampness and dripping of water from the ceiling. When this condition developed it became desirable to take air from the engine room through the air washer and to discharge it back to the room during cold and moist weather, and to regulate the room temperature by doors or openings to the boiler room. This arrangement is shown in Fig. 1. After the air passes through the generator and its temperature is raised approximately 20 deg. C., its ability to absorb moisture is greatly increased; and when discharged into the station toward the ceiling it reduces the relative humidity. The temperature of the station was regulated by opening the windows. This is the usual ventilating arrangement at the present time, but there are conditions

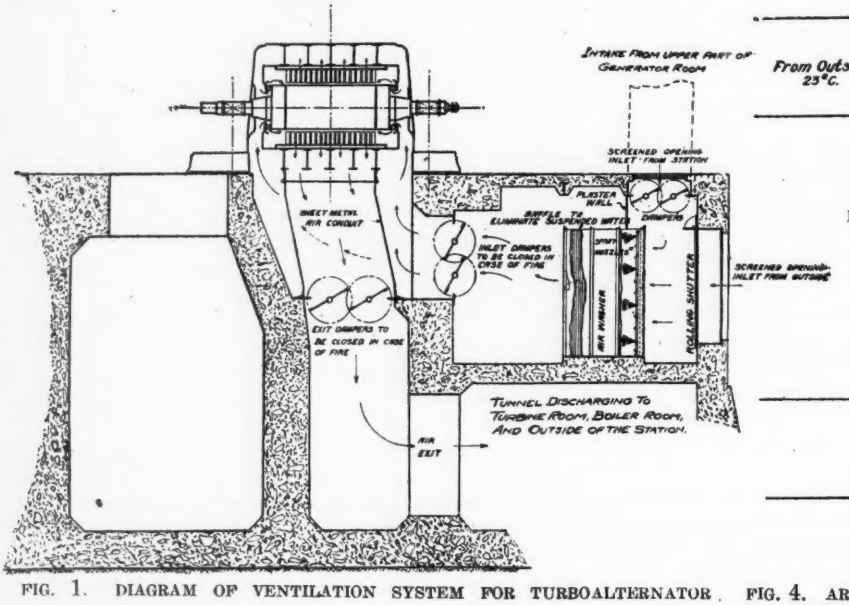

Intake From Upper Part of Generator Room
Screened Opening Inlet From Station
Plaster Wall
Sheet Metal Air Conduit
Inlet Dampers To Be Closed In Case Of Fire
Exit Dampers To Be Closed In Case Of Fire
Air Washer
Rolling Shutter
Screened Opening Inlet From Outside
Tunnel Discharging To Turbine Room, Boiler Room, And Outside Of The Station.
Air Exit

FIG. 1. DIAGRAM OF VENTILATION SYSTEM FOR TURBOALTERNATOR

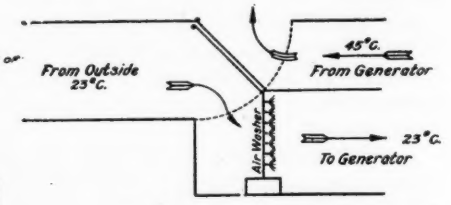


FIG. 3. ARRANGEMENT OF DAMPER TAKING AIR FROM DISCHARGING IT TO THE OUTSIDE

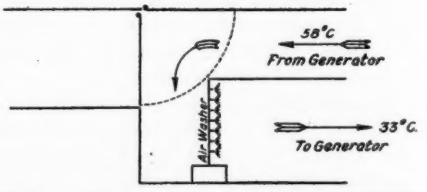


FIG. 4. ARRANGEMENT OF DAMPERS FORMING A CLOSED CIRCUIT FOR VENTILATING AIR

where a closed air system is preferable, as mentioned earlier in this article.

Closed Air Circuit System

In some cases insufficient consideration was given to the installation of washers and they could not be operated in freezing weather. In other cases the washers were not kept in good condition and failed to clean the air properly. These conditions were detrimental to the generator and a better ventilation arrangement was desirable. It is believed that this has been found in the closed air circuit system.

The closed air circuit system operates in the following manner: Air enters the rectifier cooling chamber directly after leaving the generator, then flows to the speed reducing chamber, where the water particles are segregated from the air flow, then through an eliminator chamber where the last vestige of water is removed from the air before it re-enters the generator. This system uses the same air continuously, and can be made to occupy a relatively small and compact space as compared with the present system.

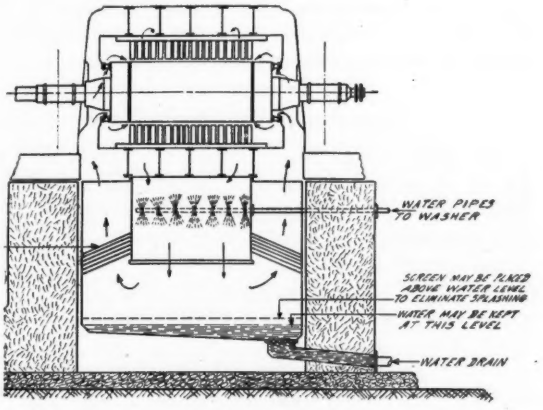

WATER PIPES TO WASHER
SCREEN MAY BE PLACED ABOVE WATER LEVEL TO ELIMINATE SPLASHING
WATER MAY BE KEPT AT THIS LEVEL
WATER DRAIN

FIG. 2. SYSTEM OF VENTILATION IN WHICH INLET AND OUTLET AIR DUCTS AND AIR RECTIFYING EQUIPMENT ARE LOCATED UNDER GENERATOR FOUNDATION

The foundation directly under the generator is usually provided with a space which is occupied by the inlet and outlet air duct pipes. This space can be utilized to advantage for mounting the air rectifier, as shown in Fig. 2. The cumbersome station ventilating ducts, including the room occupied by the air washing apparatus, will be eliminated, thereby simplifying the station construction considerably and saving space.

As stated before, the air washer is used for cleaning and cooling the incoming air. By using the same air continually, and without any possible way for it to mix with impurities, the problem of cleaning is eliminated.

Figure 2 shows a view of the rectifier installed with a generator; the complete construction consisting of a steel tank having an inner compartment where the cooling water spray nozzles are located; a separating chamber where the heated water is collected from the air and discharged; and the eliminator compartment through which the air has to pass before re-entering the generator. The operation, simplicity in design, economy of space, and positiveness of action can readily be understood.

All high speed machines are more or less noisy when the air is discharged to atmosphere, but in the closed air system this should be reduced to an unobjectionable tone and volume.

Amount of Water

The necessary quantity of water for removing the generator losses from the heated air is approximately 4 gal. per kilowatt-minute for one deg. C. rise of water, and varies inversely as the allowed temperature rise of the water. Sufficient data are not now available to determine how many degrees centigrade the cooling water should be allowed to rise to obtain the best results from the generator; but there is a considerable saving in the quantity of water used, as compared with the present air systems, when the water from the washer is heated only about 2 deg. C.

Regulating Generator Heating

As a rule, turbine units are seldom operated at their maximum output and it would therefore be inefficient to operate the air rectifier continuously with the amount of water corresponding to the maximum load of the generator. Under such load conditions, and especially when water is scarce, an automatic water regulator should be installed for controlling the number of spray nozzles in operation. There are several ways to accomplish this: By electrical and mechanical arrangements for opening and closing the valves of the water supply pipes to the spray nozzles at prearranged temperatures; by the use of thermostats placed in the heated air leaving the generator, or in some other suitable location, etc. With such automatic regulation the generator will operate at practically constant temperature for different outputs and be entirely independent of surrounding atmospheric conditions. This cannot be accomplished with present systems because the air washers used are built for a combination of cleaning and cooling; i. e., any reduction in the quantity of water may adversely affect the cleaning of the air.

Practically all air washers have the flow of air through the washer in a horizontal direction so that the drops of water, after leaving the nozzles, must fall to drip-pans at right-angles to the air flow, which has a velocity of 500 to 1000 ft. per minute. In some cases where the washers are not of liberal dimensions, small particles of water are carried along with the air flow and may enter the generator. In the system shown in Fig. 2 the air flow is vertically downward after leaving the spray chamber so that the water has to drop straight with the air flow. The direction of the air flow is then reversed to vertically upward at a speed of 300 to 500 ft. per minute before it passes the eliminator plates. The low velocity, vertical flow, and eliminator plates effectively remove all particles of water from the air before it re-enters the generator.

In the present system, the air intake or outlet ducts or both are generally supplied with dampers installed for modifying the incoming air temperatures, and to prevent air circulation in case the armature winding should take fire. The object is to let the fire smother itself; but on account of the difficulty of preventing leakage past the dampers, this method has not been entirely satisfactory for the purpose.

In the closed system dampers are unnecessary, since the amount of water controls the temperature. In case of internal fire the water valves may be closed, which would prevent the air rectification and by this means the fire would be soon extinguished. In case a quicker action is desired, steam or pyrene may be injected in the system or water can be sprinkled directly on the windings by pipes installed for this purpose.

Danger Signal

The closed air system cannot operate without cooling water being supplied to the rectifier any more than bearings can operate without lubrication. It will, therefore, be prudent to install an alarm device which will announce danger in case the water cooler does not function properly, or stops entirely; and which will also serve as a telltale should the generator happen to operate above normal temperatures from other reasons, such as heavy overloads, internal fire, etc.

Such an alarm system can be readily installed and may consist of a thermostat in the outgoing air duct, in connection with a bell that will ring at a predetermined temperature or of an electric bell connected in circuit with one or more of the stator temperature coils; also temperature coils may be mounted in the outlet air ducts in the same manner as the thermostat.

Other Applications of the Closed System

The closed air circuit system is useful not only for ventilating turbine generators and other electrical apparatus, but should prove of value in places where fumes from acids, carbon and steel dusts, or other injurious substances prevail, as it will safeguard men and machinery from their effects.—General Electric Review.

Castor Oil vs. Belt Treatment

By N. G. Near

In the March 15 number of Power Plant Engineering, page 356, is a letter by H. W. Rose in connection with a belt problem, in which he says: "The belt should be run at about half speed and an occasional application of castor oil should be made to its face to limber it up."

While it is true that castor oil is better than nothing at all, the writer is unable to understand why castor oil is so frequently recommended for application to belts when it has been proven time and again to be harmful to the belt's fibers. What is more, it does not prevent slip as well as a treatment made especially for belts.

The writer has in mind a 12-in. belt which connected a 4-ft. driving pulley running at 213 r.p.m. to a 14-in. driven pulley. This belt drove a 682-light dynamo and even when treated with castor oil, had to be run very tight, with a man constantly at hand to prevent slipping off the pulleys. When a belt slips, the lights, of course, are bound to flicker. Later on, a belt treatment made especially for belts was applied and the drive was so improved that an 850-light dynamo was substituted for the 682-light dynamo. In spite of the 25 per cent load increase, the same belt now runs quite slack, does not slip, and requires no attention.

Castor oil is gummy. The gum in solution is carried in and among the belt fibers as far as the oil penetrates. The liquid parts of these oils slowly dry out and leave the gummy element, which continues to stiffen and sooner or later become hard enough to crack. When these elements do crack, the belt fibers crack with them. This is the explanation of the fine transverse cracks, particularly across the backs of belts which have had any extensive treatment with castor or linseed oil. It is these same gummy elements that make a belt so treated look slick and smooth and, in a measure, lessen its tendency to slip. Both of these oils also decompose into harmful fatty acids. Proof of the decomposition of castor oil is obtainable by placing some in an uncorked bottle, setting this in strong sunlight or in a warm place and in time observing the changed appearance.

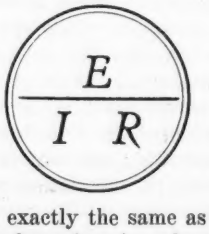
Cases are on record, also, where castor oil has caused leather belts to rot. By saturating a piece of leather belt with castor oil and placing near a radiator or other warm place, it will be found that the castor oil will decompose and will then attack the leather, causing it to become so weak that it can be easily torn with the hand.

It is therefore evident that in the end, treatment of belting with castor oil is uneconomical. It may not cost as much per pound as a treatment made especially for belts, but it will cost far more in the end, and the writer certainly would not recommend it.

Simplicity of Ohm's Law

In Power Plant Engineering for March 15, I note that J. B. Dillon suggests a method for remembering Ohm's Law. The average man remembers that Ohm's Law is expressed by a formula containing the three letters, E, I and R; but in the moment of necessity, their mathematical relation is somewhat hazy, unless he has some source of information whereby he can remember this relation.

While I was stationed at the Radio School for Mechanics, at Pittsburgh, during the war, I learned a method which is as comprehensive and as simple as anything I have ever seen along this line. The following diagram explains the system. Begin by drawing a circle. As Mr. Dillon says, E is high, so place it at the top of the circle and the I R at the bottom as shown.



This relation is exactly the same as they will occupy in any of the three formulas; i. e., by taking one letter, the unknown, out of the circle, the remaining letters will be its equal and have the same value as indicated by their position within the circle. For instance, we require the value of E; taking it out of the circle, we have I R which is its equal, or if we require the value of I, take it out of the circle and we have E over R. R taken out will leave E over I.

L. V. Andrews.

An ounce of fire prevention is worth a pound of fire extinguishment.

Hints on Refrigeration Practice---II

PRECAUTIONS REQUIRED WHEN CHARGING SYSTEM; SUITABLE PACKINGS FOR MACHINES. BY A. G. SOLOMON

ANOTHER question often confronting the refrigeration man is the precaution in charging ammonia direct from cylinder through the machine into the system while the plant is in operation.

Ammonia should be charged into the system at a point where it will do work of taking up heat before going to the compressor. The drums should be connected to a charging line located between the master valve and the expansion valves. In this way, the liquid from the drum will be circulated through the evaporating coils and useful work of heat absorbing will be done.

The master valve is closed and the valve on the charging line and on the drum are opened wide. When charging in this way, the expansion valves need not be disturbed. The pumping down that the part of the system will get while the ammonia is being put in will do good, as it will liven up any sluggish liquid that may be lying in the coils. Charge into the low back-pressure side of the system through the sharp freezer coils.

If the ammonia is charged direct into the suction side of the compressor, there is danger of slugging the compressor with liquid if the valve on the drum is opened more than just enough to allow the liquid to expand into the charging line that connects the drum to the compressor.

When charging ammonia in this way, it is common practice to close the suction stop valve at the compressor so as to be sure that all the ammonia is taken out of the drum. During even this short time, air is liable to enter the compressor through the piston rod packing.

To charge in this manner, the drum is connected to the charging line and the charging valve is opened wide. Then the valve on the drum is opened just enough so that the ammonia is heard passing through. If the valve is opened too much, the compressor will knock, as the liquid will fill the clearance space between the piston and the compressor head. This excess liquid will also cause a great drop in the temperature of the discharge line which can easily be the cause of leaks at the flanges.

As the liquid is taken from the drum, the valve can be opened a little more. By keeping close to the drum and listening, a whistling sound will be heard just as the liquid reaches the bottom end of the bent pipe that extends from the valve to the inside of the drum. The frost will now leave the charging pipe and the bottom of the drum will get cold.

The valve can now be opened wide, as all danger of liquid slugging is past. Next slow the machine down so that it is just turning over and shut the suction stop valve. This will put the compressor pulling direct on the drum alone.

Be sure that the liquid injection valve is closed if the compressor is provided with this means of cooling. Also shut off the oil supply to the rod as the vacuum will empty the oil tank or lubricator.

Not more than two or three strokes of the piston will be needed to pull a vacuum on the drum. Then close the charging valve and open the suction stop valve

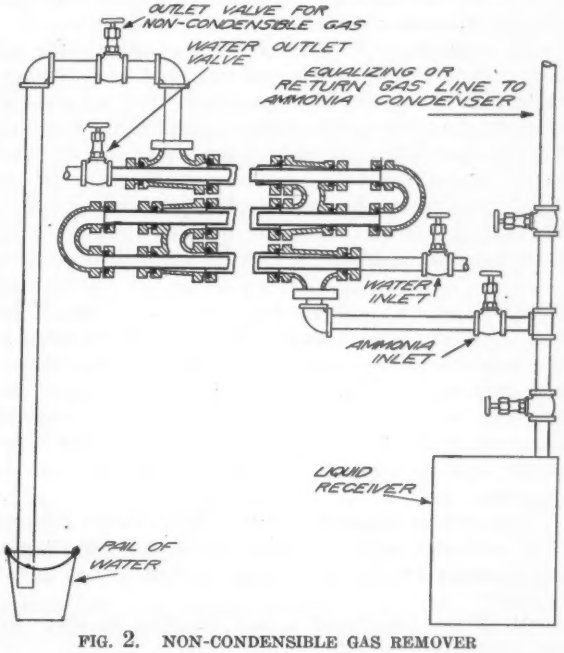


FIG. 2. NON-CONDENSIBLE GAS REMOVER

slowly. If not watched closely, the machine will stop, owing to the increased back pressure that will be on the compressor. Open the valve slowly till it is wide open and be sure that there is no liquid entering the compressor. Then put the machine up to speed again. If the expansion valves were closed off some while charging, they should be set just before the machine is speeded up. This is done to prevent unnecessary pumping down.

EFFECT OF HOT GAS ON LIQUID AMMONIA

THERE should be no great amount of non-condensed

gas passing from the condenser to the receiver if the ammonia is kept in a pure state. The gas that collects in the top of the receiver is very light and will rise to the top or gas space of the condenser through the relief line provided. If no line is there, this gas will simply pass through the expansion valves and to the evaporating coils with the liquid.

The hot discharge gas from the compressors does not come down through this relief line as the light gas is passing up; the pressure at the receiver is slightly greater than it is at the gas space of the condenser, owing to the weight of the liquid flowing from the condenser through the liquid line.

A scheme that I have tried out with great success may be of interest. At a convenient point in the gas relief line, insert a tee and connect into the bottom of a three or four-pipe section of double-pipe condenser. At the top opening place a ½-in. valve, from which extend a line downward so that the open end will be submerged to a depth of about 6 in. in a pail of cold water. Circulate cold water through the inner pipe the same as in a double-pipe condenser. The ammonia and water will have the same direction of flow, as both will travel upward. Very little water is needed, as there is no heat to remove. The idea is simply to condense and return to the receiver any liquid that is contained in the gas.

The sketch, Fig. 2, will make the connections, and also the operation, plain.

To operate: Close the valve that allows the gas to return to the condenser and open the one that connects with the double-pipe gas extractor. Let a small amount of cold water circulate through the inner pipe. Fill the pail with cold water. In about an hour just barely unseat the valve at the top, or outlet, of the double-pipe coil and watch for bubbles of air rising in the pail of water. When the bubbles appear set the valve so that bubbles will rise in the pail about once a minute. This is fast enough, so do not try to force it any faster. Keep a watch on the pail and see if the bubbles continue to appear. In a system as large as the one referred to, this non-condensible gas remover will operate day and night and will be found to perform its work in a most surprisingly satisfactory manner. The non-condensible gases will be removed slowly but surely and purging at the condensers will not be necessary.

Many times engineers are at a loss to know whether it is advisable, after pumping down, to open quickly the master valve between liquid receiver and evaporating coil.

It is not considered a safe practice to open any valve suddenly.

After the master valve has been closed for some time (the expansion valves being left open) there is considerable difference in pressure between the two sides of the valve. On one side of the valve disc there is condenser pressure, while on the other side there is back pressure. The pressure difference will be about 180 lb. in most plants. The temperature difference will be about 75 or 80 deg. F., as the one side of the valve will have the temperature of the liquid as it leaves the condenser, while on the other side the temperature will be that of saturated ammonia vapor at the back pressure.

The sudden shock of turning this warm, high pressure liquid into the cold line having scarcely any pressure may result in leaks. The leaks are most likely to occur at points where the ammonia makes a sharp turn, such as at an ell or at an expansion valve.

Packings for Refrigeration System

The first consideration, when thinking of packing, is the condition of the rods and valve stems. Piston rods must be true and smooth throughout their whole length. Worn or scored rods cannot be packed tight with any kind of packing. A rod that is even slightly bent cannot be expected to hold tight at the stuffing box.

Worn or pitted valve stems give the same packing trouble as worn rods.

Next in importance is the true travel of the rod. The rod must be central in the stuffing box. The piston must be central in the cylinder, and the piston rod must be central between the guides.

Worn valve gear will allow the valve stems to travel untrue and this will cause packing trouble. On Corliss engines the valve bonnets must be bored out and bushed and the valve stems turned down as often as wear shows.

At any time that an engine is shut down for as long as a full week, the packing should be removed. The same packing can be dipped in oil and used again. Allowing the packing to stay in will cause pitting of the rod or valve stem.

It is a mistake to add a ring of packing to a stuffing box time after time and not remove the old packing at the back end of the box.

When a rod has been newly packed do not tighten the gland more than just finger tight till the packing has become heated by at least ½ hr. running. Give the new packing a chance to expand.

The packing of all stop valve stems (ammonia, steam, air and water) need oil once in a while. Take a pail of graphite and oil and paint the stems, then open and close the valve two or three times. This will work some oil into the packing.

Lubrication of piston rod packing is important. Steam piston rods generally get enough oil from the steam cylinder lubricator, but it is a good plan to use a brush or swab and give the rod a little graphite and oil on its travel into the stuffing box.

Ammonia rods are, as a rule, provided with oil lanterns so that a supply of oil is always in contact with the rods. Care must be taken in the packing of the rods so that the oil lantern is in communication with the openings through which the oil enters and the ammonia escapes to the suction line.

Sudden changes of temperature must be avoided in the ammonia compressor. Do not "freeze up" the machine, and then shut off so much on the expansion valves that the frost all leaves the suction in a hurry. Handle the expansion valves with care and keep the temperature of the ammonia suction and discharge from sudden changes and the packing will give little trouble.

Metallic packing gives good service in the stuffing boxes of steam piston rods and steam valve stems, but it is found to be troublesome when used to pack ammonia rods. The sudden changes of temperature will ruin metallic packings much quicker than it will

fibrous; and it is an easy matter to repack a rod with fibrous packing in a short time, while it may take several hours to remove a burned set of metallic packing and insert a new set.

Rings of fibrous packing, cut at the factory exactly to fit the rod and stuffing box, will be found both convenient and satisfactory. It is a good plan during the winter overhauling season, to caliper carefully all rods and valve stems and the inside diameter of the stuffing boxes. Then send to the manufacturers of some reliable packing and have a set of cut packing sent for each rod and valve stem. Do not order more of this cut packing than will be needed for one season, as packing will not keep in good condition from year to year; and the chances are that some of the rods and stems will be worn and need turning down. This would leave odd-sized packing on hand that could not be used anywhere.

Refrigeration Machinery Lubrication

Characteristics of Oils Most Suitable for Various Services; Oil Extractors

ESSENTIALLY the equipment for compression refrigeration consists of three parts, a compressor, a condenser, and an evaporator or refrigerator. There are important auxiliaries, of course; but it is with the compressor that this article is chiefly concerned.

In operation, the refrigerating agent in liquid form passes from the bottom of the condenser through a properly adjusted valve to the evaporating or refrigerating coils in a continuous stream. In the refrigerating coils, the liquid encounters a pressure of from 10 to 25 lb. per square inch, depending upon the temperature required outside the coils. As a result, heat passes from the substance outside the coil and is absorbed by the liquid which is then converted into vapor. Passing through the refrigerator the cold ammonia vapor is drawn into the compressor at a low temperature and compressed to a pressure of from 125 to 185 lb. or over. Due to the work expended in compressing the vapor its temperature is raised, but as most cylinders are water cooled the temperature rarely exceeds 250 deg. F. From the compressor the hot vapor passes through an oil extractor to the condenser, in which it is again condensed to liquid thus completing the cycle. The discharge temperature is that at which ammonia gas will condense under existing discharge pressure.

Ammonia is compressed in one of two ways:

(a) By the wet method.
(b) By the dry method.

The object of the wet method is to prevent an undue rise in the compression temperature. To bring this about the regulating valve is set so that a little more liquid than can be evaporated is passed into the refrigerating coils. This liquid enters the compressor with the vapor and is evaporated there on the suction stroke by the heat of the compressor, its presence serving to keep the temperature of compression down.

Operators using the wet process are never certain that the excess liquid has completely evaporated at the end of the suction stroke. Unevaporated liquid constitutes a complete loss as it fills up the clearance space and in expanding occupies a considerable percentage of the compressor's capacity. To avoid this condition, compressors designed for wet compression are often operated at higher discharge temperatures. These temperatures very seldom exceed 200 deg. F., however. Theoretically, the wet method is more efficient than the dry, but in practice it is less efficient because of the quantity of ammonia which passes into the compressor in liquid form.

Compressor Lubricants

In selecting an oil for wet-compression machines it is necessary to choose one which will remain a fluid at the minimum temperature in the expansion side of the system, and of sufficiently high flash point to prevent distillation at the discharge temperature, but as the discharge temperature is comparatively low the cold or pour test and viscosity are the only important factors.

In the dry method, vapor alone is drawn into the machine, that is, the ammonia gas entering the compressor will be slightly superheated. The majority of machines operating in this class of work are vertical single-acting compressors with water jacket.

A great many horizontal spherical head double-acting compressors with and without water jackets are operated under these conditions. Discharge temperatures in the dry process will vary according to different conditions and methods of operation from 200 to 280 deg. F., and under very extreme conditions may, at times, reach 320 deg. F.

An oil for this class of work should have a sufficiently low pour test to remain a fluid at the minimum temperature in the evaporating side of the system, a flash point high enough to stand the discharge temperatures without distillation and enough viscosity to lubricate the compressor parts and seal the piston rings and compressor valves. As cylinder temperatures are considerably higher in dry compression than when the wet method is employed, it is desirable that an oil having a higher viscosity be used, and, in addition the oil should have a flash point sufficiently high to prevent distillation or cracking at the discharge temperature. A good ammonia oil should have a flash point at least 25 deg. F. higher than the average discharge temperature.

We may divide the different types of ammonia compressors into four general classes:

(a) Vertical single-acting compressors.
(b) Horizontal double-acting compressors.
(c) Enclosed high-speed compressors.
(d) Rotary compressors.

Vertical single-acting compressors are built in various sizes from one-eighth ton capacity upward. The smaller types of these are usually lubricated by the splash system in a manner similar to that employed in automobile engines. When the back pressure drops below atmospheric in this type of machine there is always danger of oil being drawn into the cylinder, but this will never occur if the attendant watches his gages

closely and maintains the back pressure at the proper value. The ammonia piston used in a great many of these machines is of the double trunk type, with the charge entering between the upper and lower sections. The upper section is fitted with two or three rings and also contains a valve. The lower section carries one or two rings which form a seal between the crank case and the suction of the machine. These serve to prevent excess oil from being drawn into the cylinder when the back pressure drops. A light oil gives satisfactory results upon this type of compressor.

Vertical machines are built with from one to four cylinders. In the larger sizes the lubrication of the working parts is accomplished through the use of a force feed circulating system. In machines using the splash system it is important that the oil level in the crank case should not be kept too high. A high oil level causes excessive churning and is liable to lead to the introduction of oil into the refrigerating system.

Some double-acting compressors are lubricated by introducing the oil at the piston rod stuffing box, which is fitted with an oil lantern. The small amount of oil working into the cylinder past the packing is found to afford ample lubrication. When this method is employed it is found that the oil protects the packing from the injurious action of the hot ammonia gas. The De La Vergne compressor is lubricated in this manner. Other compressors are lubricated through the use of positive force feed lubricators, but where these are used precautions should be taken to see that they are constructed entirely of iron or steel. No copper or copper alloys should be used about an ammonia compressor. These lubricators assure efficient lubrication, in that they put the right amount of oil in the right place at the right time, and do this at the minimum cost.

Lubrication of the bearings of a compressor presents no unusual difficulties. When the splash method of lubrication is employed and one oil is used for both the cylinder and the bearings an ammonia oil of some type must be used, but when the oil is not used in the cylinder any high grade non-emulsifying oil may be employed. The same grade of oil may also be used when a circulating system is employed. When the oil is fed from cups or a force feed lubricator any high-grade engine oil will prove satisfactory, the viscosity, of course, being suitable for the weight and speed of the machine in question.

Selection and proper application of a suitable lubricating oil for the ammonia compressor is one of the duties of the lubricating engineer and a question of much importance to the engineer operating a refrigerating plant. In selecting an oil the character of friction, pressure, temperature and velocity and position of the moving parts, as well as the chemical nature and the composition of the lubricating oil must all be considered. Some attention must also be devoted to the chemical properties and temperature of the materials with which the oil may come in contact.—Lubrication.

(To be continued.)

Fire Extinguishment

Prepared by the Engineering Department of the National Safety Council

PRACTICALLY every fire can be extinguished within the first 5 min., if proper equipment is brought into use by men who know how to use it. Successful extinguishment of fires does not, in general, require elaborate, expensive equipment; the essentials are the right kind of equipment (suited to the existing hazards) kept in good condition, in the right place, with men who know how to use it, and that it be brought into use immediately after the fire starts. No matter how well equipped a plant is with fire-fighting apparatus, nor how well trained the men may be to handle this apparatus, it is of the utmost importance that the public fire department be notified immediately when fire is discovered.

Sprinklers

The automatic sprinkler is considered the most important of all fire-extinguishing apparatus.

Water shut off from sprinkler pipes is the most frequent cause of unsatisfactory control of fire by automatic sprinkler systems. Inspections often reveal that the control valves are closed and that, therefore, the sprinklers would be practically valueless in case of fire. A safeguard against this contingency is to seal or strap the water-control valves in open position; this will tend to prevent malicious or careless closing of the valves. An electrical signaling device which, whenever the normal position of any valves is disturbed, will automatically signal a central control station, is also an efficient safeguard against closed valves.

Another serious condition which often results in the failure of sprinklers to efficiently control a fire is caused by the piling of stock, and building of shelving and partitions too close to the sprinkler heads, so that they obstruct the proper distribution of water over the surrounding area. At least 24 in. clear space should be maintained below the sprinklers so that an effective spray action of the heads will be possible.

Hose

It is almost impossible to tell good from bad rubber-lined hose when it is new, either from its appearance or by putting it under pressure. It is recommended, therefore, that only hose bearing the label of approval of Underwriters' Laboratories be purchased. Hose should not be kept in a pump house, boiler house, or other warm place, as rubber quickly deteriorates under such conditions. Where hose is folded on shelves or racks it should be changed from time to time with bends at different points to prevent cracking.

Water Pails

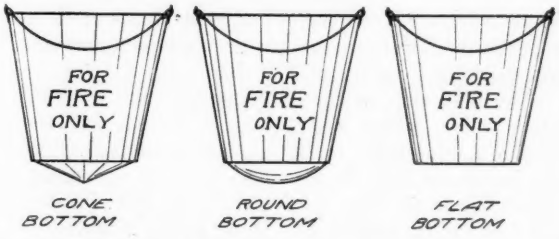
Cone or round-bottom pails are preferred by many, as they are less likely to be used for other purposes. The flat-bottom pail (bucket) of about 3 gal. capacity is, however, recommended; for if an employe carries two pails to a fire, he may set one down while he empties the other. Fire pails, water barrels and water casks should be painted red with the word "fire" in white letters on them. Their use for purposes other than fire-fighting should be strictly prohibited.

Soda-Acid Extinguishers

The soda-acid extinguisher in common use employs a solution of about 1½ lb. of bicarbonate of soda to 2½ gal. of water, with an inner container of approximately 4 oz. of sulphuric acid. These are made in the "loose stopple" and the "break bottle" types. The latter are especially adapted for railroad and boat service where swaying and rocking would splash the acid over into the soda solution, thus rendering it useless. By inverting the extinguisher or breaking the bottle, the acid is emptied into the soda solution, forming a gas the expansion of which forces out the solution under considerable pressure.

These extinguishers are valuable in free-burning fires where there is much draft. They are also of value in fighting fires on ceilings or between walls where it cannot be reached by fire pails. Sizes larger than 2½ gal. capacity are not recommended because of the inconvenience in handling.

Soda-acid extinguishers must be protected against freezing and for this reason are of little value in locations where protracted cold spells prevail unless they are kept heated. Cabinets (felt or asbestos lined) containing a small electric light beneath the extinguisher, will be



THE FLAT-BOTTOMED PAIL IS PREFERRED TO THE CONE- OR ROUND-BOTTOM TYPE, AS IT CAN BE STOOD ON THE FLOOR

adequate protection against the cold. A red glass in door of cabinet, through which light may be seen, will serve to mark the location of the extinguisher box.

The acid in the extinguisher constantly absorbs water, and, in time, enough water may be absorbed to cause the acid bottle to run over, and acid dropping into the tank will eat into the side of tank around water line. It is advisable, then, that new acid be placed in the bottle once each year when extinguisher is recharged.

Soda-acid extinguishers should be recharged at least once a year. They should be emptied by inverting and playing through the hose as if on a fire, to insure the operation of the extinguisher and also to give employes an opportunity to see how they are operated. Before recharging, the hose and the extinguisher tank should be thoroughly washed.

Carbon-Tetrachloride Extinguishers

Carbon-tetrachloride, when heated to about 200 deg. F., is transformed into a gas heavier than air. When thrown on a fire the gas surrounds the fire area, keeping out the air and oxygen, and tends to smother the fire. As the extinguishing value of carbon-tetrachloride depends on the smothering effect of the gas, these extinguishers are of little value where there is a wind or other current of air which will carry the gas away from the fire. A fire in freely-burning material, such as wood or paper, quickly creates a strong draft of air inward and upward, and such fires are difficult to extinguish with carbon-tetrachloride except when they are very small. This type of extinguisher is useful, however, for reaching fires in partitions and other concealed spaces.

Extinguishers containing this fluid are of particular value for electric fires, as the carbon-tetrachloride is a non-conductor of electricity and will not injure electrical apparatus. The stream may be directed on the commutator of a dynamo without danger to operator or machine. Carbon-tetrachloride extinguishers are recommended for all electric cranes, at motor (wherever located), and at convenient points in power houses.

Carbon-tetrachloride does not deteriorate with age, nor freeze at usual temperatures, and if mixed with a small per cent of certain other ingredients will withstand a temperature of 50 deg. F. below zero.

AT THE LEFT A STANDARD 2½-GAL. SODA-ACID EXTINGUISHER; AT THE RIGHT ONE OF THE CARBON-TETRACHLORIDE TYPE

Carbon-tetrachloride extinguishers should be tested periodically to see that the pump has not gummed, which would interfere with its free action. It is suggested that twice each year all extinguishers be tested by discharging (by pumping) all the contents into a pail. The pump should then be operated vigorously to make sure that it works freely, and that the packing is flexible. Then the fluid should be replaced, a little being added to fill the tank. Particular care must be taken that no water becomes mixed with carbon-tetrachloride used in extinguishers, as water will reduce its non-conductivity.

Sawdust and Soda

A mixture of sawdust and bicarbonate of soda (about 10 lb. of soda to a bushel of sawdust) is a valuable extinguishing agent in fires of inflammable liquids. This mixture floats on the surface of the burning liquid, shutting off the oxygen supply and smothering the fire. It is much more effective than sand in putting out fires of inflammable liquids. Unless foam extinguishers are provided, a supply of sawdust and soda should be kept

on hand at all containers of varnishes, lacquers, oils, paints, and similar liquids.

Suggestions

The efficiency of fire-fighting apparatus depends largely upon its proper use. Unless the hose stream, the extinguishing fluid, sand, or sawdust is directed on the base of the fire, its value is lost. Employes should be instructed in the proper use of all equipment, and given an occasional opportunity of seeing it in actual operation.

Fire extinguishers and fire hose racks are sometimes found inaccessible on account of material stacked in front of them. It is also a fact that the employes in many plants do not know where the fire apparatus is located. To be of value, such apparatus must be put into use immediately after fire is discovered. It should, therefore, be placed prominently and kept easily accessible. Some plants place extinguishers along center aisles with a red mark on floor or around column or post on which extinguisher is hung, and often with a red light over it at night.

Inspection should be made of all fire-fighting apparatus, including extinguishers, fire barrels and pails, hose, hydrants, and valves, at least once each week. Many of the large companies require such an inspection every day. A competent man should be assigned to this inspection service and should periodically make a complete and detailed inspection of all apparatus and equipment, keeping a record of the inspection on a blank for that purpose.

Purposes of inspection are to determine (a) what possibilities of fire outbreak can be eliminated, and (b) whether fire-fighting equipment and apparatus is in good condition and accessible.

It has often been the case that extinguishers were found empty when most needed. In order to know at a glance whether an extinguisher has been tampered with, through mischief or maliciously, some companies use a car seal to fasten handle of extinguisher to hanger bracket. These seals are easily broken, and therefore do not interfere with use of the extinguisher. They are, however, not replaceable, and hence enable the inspector to know whether extinguishers have been disturbed for any reason.

Preventing Boiler Explosions

By C. S. Tompkins

From a study of boiler explosions, which are of much too frequent occurrence, it is apparent that boiler inspectors are often tempted to allow too high working pressures, with the result that property and lives of the engineers, as well as other employes, are unnecessarily exposed to danger.

An example of this practice is the boiler of a Minneapolis laundry, which exploded several months ago. The boiler in question was of the return tubular type, 66 in. in diameter by 18 ft. in length. The shell steel was 7/16 in. thick, with a tensile strength of 55,000 lb. The longitudinal seams were triple-riveted butt joint construction, but, on account of having been damaged, the lower half of the sheet, directly over the fire, had subsequently been replaced by what is known as a half-sheet patch. The longitudinal seams employed in making this repair were of double riveted lap joint construction, and located below the hangers by which the boiler was suspended. The joints were thus exposed somewhat to the heat of the fire.

The boiler, which, according to the insurance company's records was 15 yr. old, was inspected regularly by the insurance underwriter's inspector, and was there-

FIG. 1. DESTRUCTION CAUSED BY TYPICAL BOILER EXPLOSION

fore exempted by the Minnesota State Laws from state inspection. The insurance inspector allowed a maximum safe working pressure of 110 lb.

The first step in the investigation was to test the safety valve, which was found to release at 110 lb. Within 2 min. prior to the explosion, the safety valve was known to have blown. The force of the explosion was sufficient to move the boiler 50 ft. from its setting and force it through a 3-ft. stone wall. A part of the

FIG. 2. THE TOP EDGE SHOWS WHAT WAS LEFT OF A DOUBLE RIVETED LAP JOINT USED IN PUTTING ON A PATCH

boiler front was thrown nearly a city block. Figure 1 shows the boiler end projecting through the stone wall. Figure 2 shows one of the points of failure, the man's right hand touching the original triple-riveted joint, and his left touching the remains of the lap joint.

Paragraph 187 of the Boiler Code of the American Society of Mechanical Engineers, which is standard in Minnesota, reads as follows: The riveted longitudinal

joints of a shell, or drum, which exceeds 36 in. in diameter, shall be of butt and double strap construction. This does not apply to the portion of a boiler shell which is staybolted to the firebox sheet.

Paragraph 188 reads: The longitudinal joints of a shell, or drum, which does not exceed 36 in. in diameter may be of lap riveted construction, but the maximum allowable pressure shall not exceed 100 lb. per square inch.

Paragraph 189 reads: The longitudinal joints of a horizontal return tubular boiler shall be located above the fire line of the setting.

It will be seen that the inspector who allowed 110 lb. in the example given was very liberal. A factor of safety of five would give a working pressure of 105 lb. and a further allowance should have been made for the patch. Paragraph 188 absolutely forbids more than 100 lb. working pressure.

All engineers' organizations ought to insist upon the adoption of the Boiler Code of the American Society of Mechanical Engineers, and a strict adherence thereto by inspectors. This would eliminate to a great extent the large number of boiler explosions which occur annually.

Personality

ITS VALUE IN HANDLING MEN. BY JACK L. BALL

"BOYS, I have always thought that a man's personality had quite a lot to do with, and in some instances was the deciding factor in, his success as an engineer." It was our chief talking at a gathering of engineers and I took in every word, for he has a habit of giving good, sound usable advice when in a mood to talk. "I know that it is quite impossible for us to be a continual bundle of sunshine, as things are not always a bed of roses at the plant; but we can, with a little thought and effort, conduct our ways in such a manner that the crew will run in synchronism. This is a mighty big thing to accomplish in some instances and requires a lot of tact to get results; but if some chief engineers would just heed a few of the fundamental rules of 'good fellowship,' I believe it would prove conducive to good results in some instances and be beneficial to all concerned. What I am now going to say will hit some of you fellows rather hard, but I won't call any names.

" All of us are acquainted with the perpetual grouch, the man who never smiles. If he keeps a man any length of time, the man will turn out to be a bundle of gloom and will lack the initiative to go ahead and do anything for fear of displeasing his superior. They both carry a heavy load, not an asset to be proud of, but a liability of which they ought to be ashamed.

"Human nature is a broad, deep study that no man has ever mastered. We can't handle every man in the same way. Some men respond to kindness in a command; others like the rough jest, joking, firmness and so on. I have known a few exceptional cases where men, working on an emergency job, liked to be cursed back and seemed to derive a pleasure therefrom. You will find though, that any order given in a firm, kind manner will bring a response from your men in a surprising way.

"I was in a plant the other way when the boys were having a little trouble. The oiler had 'run' the babbit on the crank of a small engine so that re-babbiting was necessary. The man in charge at the time was sure giving everyone in sight a going over. The whole crew was angry and nervous and several 'pours' were spoiled before the job was satisfactory. I found out later that it was not the fault of the oiler. The assistant chief is in wrong with all hands on account of a dollar's worth of babbit, a nickel's worth of patience and a bunker full of temper.

"Never question a man's politics or his religion. The constitution of the United States grants a man the right of exercising his individual opinions in any manner that he chooses as long as his actions do not conflict with the law.

"Never argue. Argument is simply a cheap form of conversation. If you are asked for information, give it if you can. If you are not informed as you should be on the particular subject, say so, but obtain the desired information as soon as you can. The very excellent engineering journals that are published contain up-to-date information on every subject of our work. If you are not informed as you should be, the other fellow might be a mint of information and the result might be an argument.

"If changes or improvements are to be made to the plant, I like to see those in charge talk the matter over with all hands. It makes the men feel that you are interested in them and that you feel that they have the welfare of the plant at heart. You will find, too, that the ash wheeler can think just the same as the general manager even if he doesn't wear a white collar; and remember that because a man is holding down a subordinate job, it does not indicate that he has an inferior mind. Likely as not, if he is a progressive fellow, he has an eye on your job.

"I went to see a fellow the other day. When I called at the plant, I found that they were having some tube trouble and that he was in the combustion chamber of the boiler that had been quickly cooled off, re-rolling tubes to beat the band. He had other men that might have done this work, but he did not ask them so they could get hot and dirty and he could keep clean. No, sir! He got right on the job and the men know that he is no shirker. There might be a time when all hands will have to do some hot, dirty and repulsive job. They will never hesitate for a minute for they know that their chief will be right there with them. When they finish, he won't hand them a line of bunk. With a few words he will let them know that he appreciates their services and they will know that he means what he says.

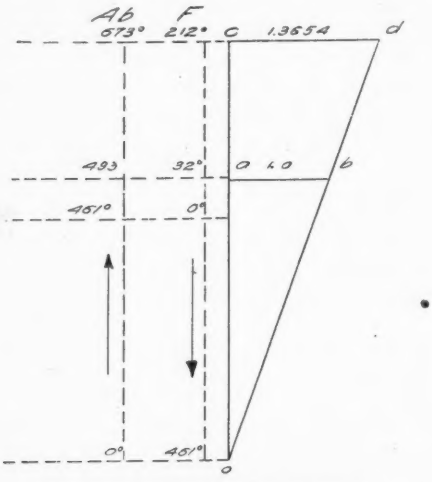
"Now, boys, I am about through, but let me add this: One of the worst things that you can do is to give a man a 'calling' in the presence of other members of your crew or when there is a stranger present. This is usually done to let somebody know that you are the boss, and eventually, will get you a bad name with the men and with your fellow engineers.

"Summed up, you will find that if you are kind, helpful, generous hearted, considerate with your help, do not shirk your study so that you will be out of date, and are always willing to help the under man you will receive your reward. This might be only the kind thoughts of your co-workers, but let me say that merited friendship is the greatest thing in the world, something that you should strive to earn by word and action."

Determining Absolute Zero

HAYMAKER'S letter, page 399, April 1 issue, has attracted my attention. That there is a difference in the numerical value of absolute temperature, as assigned by the different authorities, is due, I believe, to two things in general, and possibly more than two. One of these things is, that the weight and volume of a gas depend upon the pressure and temperature, and the temperature in turn depends upon the specific heat of the gas. The specific heat may vary throughout any given range; and so, according as to the numerical value of specific heat used in any calculation, just so will be the result. Thus, results may differ slightly.

The other thing to which I have referred is relative



ABSOLUTE TEMPERATURE DIAGRAM

to the diagram that is sometimes used to show how the absolute zero of temperature has been found. The diagram accompanies this letter. It will be noticed that the sloping line is drawn straight; that it is straight is only an assumption. It is possible, yes, even probable, that the line is not straight, but curved to a certain extent, at least, and that curvature would change the point of intersection with the vertical straight line in the diagram. A very little curvature of the sloping line would make the difference of a few degrees on the scale of the vertical line. So, it seems to me, that the absolute zero may vary slightly, as used in calculations, for the reasons that I have just given. But, the difference in the values given and used by various engineers is so little that nobody need concern himself seriously about it. In working out results, where 460 and 466 have been used respectively, a difference of less than 1 per cent only has been found. This is sufficiently close for nearly all, if not all, calculations of a practical, commercial nature.

Perhaps the following explanation and its accompanying illustration may help Haymaker to understand the problem a little better, and, from what I have said, how different numerical values for the absolute zero of temperature may be obtained.

It has been found by experiment that when air is heated or cooled, under constant pressure, its volume increases or decreases in such a way that if the volume of the air, at the freezing point of water, viz., 32 deg. F., be 1 cu. ft.; then when the 1 cu. ft. be heated to the boiling point of water, 212 deg. F. at atmospheric pressure, it will become 1.3654 cu. ft. Inversely, if the volume remains constant, instead of the pressure, and if the pressure, at the freezing point of water (32 deg. F.), be one atmosphere, then the pressure, at the boiling point of water (212 deg. F.), will be 1.3654 atmospheres.

The diagram shown herewith gives the absolute zero of temperature as 461 deg. F. below the ordinary zero on that particular scale.

This is the way the diagram is drawn. First, draw the vertical line *oc* to represent temperature; use any convenient scale. Mark the line *oc*, points to represent the freezing point of water, 32 deg. F., and the boiling point of water, 212 deg. F. From the point at 32 deg. *a*, draw the line of pressure *ab* at right angles to the line *oc*. This line of pressure *ab* is drawn to scale to represent one atmosphere. At the 212 deg. F. point, *c*, draw the line *cd*, also at right angles to the line *oc*, to represent 1.3654 atmospheres, to the same scale that the line *ab* is drawn. Now join the extremities of the lines, *d* and *b*, and continue the line so made until it intersects line *oc*. The point of intersection, when measured on the same scale that the line *oc* was drawn to, is found to be 461 deg. below the point *a* (which represents 32 deg. F.).

The foregoing explanation of the construction of the diagram is based on the following assumptions:

Since pressures vary regularly per degree of change of temperature, between certain limits within the range of experiment, it seems fair to assume that the variation will continue regularly, beyond the range of experiment, and on this assumption the 461 deg. F. point is found. This is the point at which all heat vibration ceases, and thus it is called the absolute zero of temperature, as compared with the apparent zero of temperature, as measured on an ordinary thermometer.

The problem may be better understood if stated in a simple arithmetical manner, like this:

$$212 - 32 = 180$$

Then, by simple proportion, as the distance on the

the diagram ($oa + 180$ deg.), is to the distance oa, so is 1.3654 to 1. Or,

$$(oa + 180) : oa :: 1.3654 : 1$$

As the product of the extremes equals the product of the means,

$$1 \times (oa + 180) = oa \times 1.3654$$
$$oa + 180 = oa \times 1.3654$$
$$180 = 0.3654oa$$
$$oa = \frac{180}{0.3654}$$
$$= 493, \text{ in round numbers.}$$

It will be noticed that there are two scales at the left of the diagram, one, the Fahrenheit scale, and the other, the absolute scale. By comparing the zeros of these scales, it will be seen that the absolute zero is 461 deg. below the Fahrenheit zero.

A slight curving of the line *od* inward, beginning at the point *b*, would bring the point of intersection a little lower than where it is at present, and that would account, in part at least, for the difference in the number of degrees referred to by Haymaker.

CHARLES J. MASON.

Bridging Over Difficulties; Water Softening in Small Plants

I WAS considerably interested in the experience of LeRoy Blake, as related on page 352 of the March 15 issue.

The trouble he mentions might quite readily have been remedied by removing the shaft, drilling a 3/16-in. hole through it at about the center of the pulley and inserting a pin which would project about an inch on each side of the shaft. The pulley might then be properly notched, assembled upon the shaft, and secured by means of wood screws.

On page 351, of the March 15 issue, J. B. records an interesting problem of feed-water for boilers.

I do not consider a water softening plant either practical or profitable to install and operate.

When you install a water softening plant, you increase your equipment, thereby calling for additional outlay of capital; then, they require a dead expense for upkeep; and, they are an expensive attachment to the power plant to operate. Anyway, why do all this when another method not only will accomplish the same results, but will practically treat the water so that it is satisfactory for good boiler operating at at least 95 per cent less cost than a water softening plant will do?

As a matter of fact, when it comes to a question of handling troublesome and expensive boiler feed-water, how many water softeners have made good? I will leave that question to engineers who are operating them, as I am of the opinion that any engineer who says he has a practical and economical water softening plant which is the cheapest way he knows how to purify water is either fooling himself or is lacking in experience. I take it for granted that J. B.'s boilers are not overloaded, as he states also that his steam piping is correctly installed, assisted with steam traps properly placed where they are needed, which has a very important bearing upon the successful operation of all engines.

The pitting to which he refers would require quite a tiresome chemical analysis to explain thoroughly.

The problem would have been interesting if J. B. would have given the information as to whether he was running condensing or non-condensing, and whether his boiler feed-water was from wells, creeks, risers or lakes.

If the boilers are not overloaded, however, and regardless of what kind of water is being used, as long as it is not salt water, the thing to do is to install an ordinary tank or pond, dug out of the earth. The theory of the earthen tank is that it will allow the water time to throw off a certain amount of its mineral impurities, which are disastrous and costly in boiler operation.

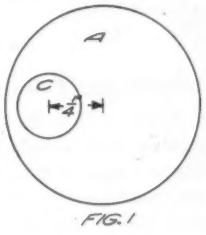
To carry the water problem to its successful end after the feed-water has left the heater on its way to the boilers in its heated stage, a sample of it, about a gallon, accompanied by at least a pound of the scale, should be sent to a good laboratory for analysis. A boiler compound should then be made up to treat the water, and not the boiler. This method is generally pursued by elevating a 50-gal. water storage tank near the feed-pump suction line with a connection between it and the suction line. Then fill the tank with water, and add to it the proper amount of chemical for the day's run; regulate by a small valve so that it will run out only during the day's run.

By following this system, your boiler room troubles are at an end.

H. W. ROSE.

Proving the Eccentricity of the Eccentric

IN THE March 1 issue, I note Roy R. Winans' "Conception of Slide Valve Travel," wherein I am sure he has the wrong conception.



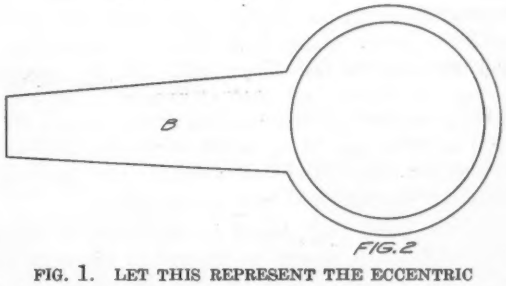


FIG. 1. LET THIS REPRESENT THE ECCENTRIC
FIG. 2. AND THIS MAY REPRESENT THE ECCENTRIC ROD AND STRAP

Referring to the graph he has shown, he states that distance B taken from C gives us the eccentricity, which certainly is an error.

The eccentricity of an eccentric is the distance from the center of the crankshaft to the center of the eccentric, as shown at D in the graph, and in this particular

case, is ¼-in. according to the dimensions given by Mr. Winans.

Distance B plus C equals the diameter of the eccentric $= \frac{10}{8}$ or 1¼ in., and one-half of this, or ⅝ in. is the center of the eccentric, distance E, and ⅝ minus distance B equals ¼ in., which is the eccentricity of the eccentric.

Mr. Winans is correct in the distance of the valve travel, which is ½ in. as shown at A, but this distance is also twice the eccentricity of the eccentric.

If Mr. Winans wishes to prove this to his own satisfaction he can easily do so by taking cardboard and cutting out a circular piece, A, Fig. 1, and let this represent the eccentric; then let piece B, Fig. 2, represent the eccentric rod and strap. On A, Fig. 1, mark point C, ¼ in. from the center of A and let this point represent the center of the crank shaft. Then, by placing piece A in hole in B, and inserting a pin at point C as a pivot and revolving A around this point, he will notice the total distance that the end of B moves is ½ in.

He will also find that by changing the distance between point C and the center of A, that the travel of the end of B changes, although the diameter of A remains the same. This proves to us that the diameter of the eccentric has nothing to do with the travel of the valve.

Mr. Winans says that, "it is an error to presume that the eccentric is only a shaft with an enlarged crankpin."

There certainly is a vast difference in the design of the two, but the function performed by them is exactly the same, as is readily proved in the shaft governor with the overhanging pin which is nothing more or less than a crank.

E. C. Wells.

Synchroscope Fault Ascribed to Generator

On page 333 of the Mar. 15 issue of Power Plant Engineering is an article which interested me very much, more on account of the things that an experienced operator can read between the lines than on account of those that were in the article.

I am a chief operator in what is about the most up-to-date steam plant in the United States and have been an operator in many plants both large and small over a period covering the last 15 yr. and, with the exception of certain apparatus not used at present, I have never seen a case where defective location of the pointer (if the pointer is off enough to cause the alternator to grunt at all) was not immediately apparent to the operator as soon as the machine had been synchronized.

Another point that should be mentioned is the fact that synchroscopes should be checked at frequent intervals. This is easily done by plugging them in on a machine that is running on the bus and noting the position of the pointer. In some plants, it is necessary to have two machines running on the bus to make this check; but there is always some time in the course of a week that it can be made. I make it a practice to check the instrument before using it in all cases except at times when an emergency calls for very fast work.

I would like to hear more about the case mentioned in the article referred to, particularly as to why they failed to note that the synchroscope failed to remain at or very close to the place where it would indicate exact synchronism after the machine was on the bus.

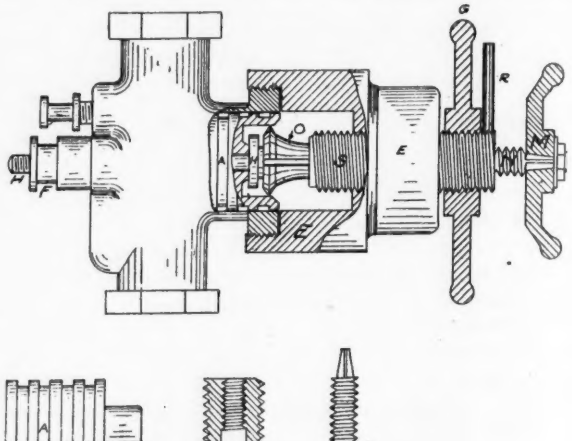
If the instrument did indicate synchronism, what kind of an instrument was it?

Edward J. Clark.

Extractor for Corroded Water Valve

When a water valve, of the John Douglass type, such as is used in plumbing work, has been idle for some time, the piston is likely to become corroded and sieze the body. Removal is then difficult. The sketches herewith show a special tool, which I designed to overcome this difficulty. The part O of the expanding member S is turned to a 60-deg. edge and hardened and ground.

When the water valve piston, shown at A, requires removal, the valve cap is removed, stuffing box, F, loosened and rod H taken out, and the special tool fitted in its place, part E being threaded to fit the valve body.



DETAILS AND ASSEMBLY OF VALVE EXTRACTOR

Expander S is then pressed against the cylinder and expanded by turning wheel, M, drawing H into S. The beveled edges at O grip cylinder A and enable it to be withdrawn by means of wheel G. Rotation of S while being expanded is prevented by holding rod R. The whole operation takes about 5 min., saving considerable time, as I have seen plumbers work for several hours without success.

Otto Dorthen.

Steam Piping

I note in the April 1 issue of Power Plant Engineering, page 400, Tom Thumb's opinion as to main line steam piping and his theory, which he refers to as the experience of a 100,000 hp. plant. In that respect, I

will say that others in plants of that size, and a few somewhat larger, have corrected such condensation troubles by draining the steam lines to the boilers instead of away from them, with the exception of cases where the steam lines were too small to convey the steam. In such cases, naturally, the velocity of steam is much greater than in a steam line which is a little bit larger in capacity than is necessary at the peak load of the plant. Where steam lines are correctly installed as to their carrying capacity, the actual life is not only considerably longer, but the lubricating bills are considerably less.

H. W. Rose.

Remarks on Issue of April 1, 1920

Under the caption, "Filing Magazine Articles," page 398, I note that Mr. Benefiel is one of the readers who realize the value of preserving for future reference the many good things found in Power Plant Engineering. How to preserve the articles of value and store them away in a manner that will permit finding what you want, and when you want it, is quite a question.

My method of preserving published articles is as follows: After reading the magazine, I lay it aside until there is the accumulation of 6 mo. or so. Then I remove the wire binders and take out all whole pages having thereon any article I desire to preserve. By this operation, the bulk is reduced very considerably.

When I have the opportunity I separate the articles according to subjects, such as—governors, safety valves, injectors, pumps, heaters, boiler design, boiler construction, boiler operation, boiler explosions, etc.

Short articles I cut out and paste on a page containing an article on the same subject, a process reducing the number of pages. I use Shipman's Common Sense Binder of the proper size for magazine pages.

When beginning the use of a binder, it is arranged for certain subjects only, allowing plenty of room for future filing. When starting a subject, I bind about 20 strips extra with each subject, these strips being cut from the advertising pages, with about 1 in. projecting, to permit pasting another page on it. This permits adding considerable on the subject without disturbing the papers already filed.

On the back of each binder is pasted a slip of paper containing the subjects bound. The index is arranged by pasting small pieces of paper to the top of the first page on each subject, having the subject abbreviated and written thereon, and projecting above the page sufficient to be seen when the book is closed.

In this manner, there is no delay finding the desired subject, but it is necessary to turn the pages if a certain article is wanted. This method of filing eliminates the labor of preparing or keeping up an extensive index.

On page 402, W. L. N. comments on questions in a previous issue. Further light may be given on question 25, to which he refers, and which reads, "Why is middle sheet fitted between the two end sheets?" This question refers to the shell plate of horizontal return tubular boilers of three-course construction.

The principal reason for placing the middle course inside the others is for strength. It is then twice the plate thickness less in diameter than if placed on the outside of the other two courses. It has been found from experience that a vessel subjected to pressure tends to stretch or expand in the middle first; by having the middle course inside the others, that section of the boiler is made stronger.

The boiler inspector will tell you that fire cracks will develop at the first girth seam or the front head seam if exposed to the fire, if scale is permitted to accumulate on the inside of the seam, or if the drift pin was used before the rivets were driven.

The scale on the inside may cause overheating and fire cracks in the outer lap of the seam because the water is too far away from the metal of the outer lap, thus preventing the heat from being absorbed quickly enough.

If the drift pin is used to bring rivet holes fair, the metal is abused and strained and may require little service of the boiler to cause cracks to develop. These cracks will develop with the girth seam outer lap edge either forward or rearward; that is, with the middle course either inside or outside.

W. L. N. states that he had charge of two boilers and that both had been bagged or depressed in the front course. The relationship of this course to the next course had nothing to do with the bagging of the shell plate.

I have seen the shell plate of the second course seriously bagged and the front course plate remaining in proper shape. The bagged plate was on the inside of the other courses in the boiler. The shell plate of a boiler can be bagged or bulged at any point if permitted to become overheated while there is pressure on the boiler.

The overheating is usually caused by mud, scale or oil in the boiler, and the neglect of permitting these accumulations has been the cause of many costly boiler repair bills.

I. B. Leavit.

I received my copy of Power Plant Engineering yesterday and wish to comment on some of the letters appearing on page 399.

In reference to Reading the U-Tube Draft Gage, by M. W. Cartee, it is my opinion that his last statement, "The difference in the height of the water in our U-tube is the draft in inches of water," is correct. However, I cannot agree with him in his statement of reading only one leg, from 0 to the level of the liquid, since the 0 point is but one-half the difference in the height of the water in the U-tube.

The difference is caused by the difference between atmospheric pressure outside and a partial vacuum inside the stack, or wherever the other leg of the U-tube is connected. The question, therefore, resolves itself into, how many inches of water will this partial vacuum sustain?

Water seeks its own level; that in the low side of the U-tube will support the water in the high side to its level, and only to its own level, the partial vacuum within the chimney; or, to be more exact, the difference between atmospheric pressure on one leg of the tube and the pressure within the chimney on the other leg, supporting the water in the high leg, from that level, to the top of the column of water in the high leg. Therefore, the draft in inches of water is the rise in one leg plus the fall in the other leg. Various devices have

been contrived to correct the error in mercurial barometers and vacuum gages caused by mercury rising in the tube and being lowered in the mercury pool below. An adjustment screw is provided to keep the mercury in the pool at the zero mark. Applying the same principle to our U-tube, if we should keep the level in the atmospheric leg at 0-point reading the other leg above 0-point would suffice, but it would be the same, as by letting the atmospheric leg fall and adding its fall to the rise in the other leg.

Much has been written about the engineers' license laws, but Joseph J. Zlabis has come pretty near hitting the nail on the head. Of course, coal operators cannot guarantee the quantity of water certain coal will evaporate, but they can guarantee and sell coal by its B.t.u. content. Then the power plant owner, if he is sufficiently interested, can get the information to ascertain how much water that coal should evaporate. And when the owners do wake up I don't think a license law will be needed for the weeding out process to take place. In fact, from the looks of the Signboard Section lately, I don't think there are any efficient boiler-room men running around loose.

While many good arguments have been advanced in favor of the license law, it is my opinion that coal prices will be the leading factor in weeding out the inefficient boiler-room operatives, and it is sure to come with the increase price of coal regardless of anything that can be done on the part of the engineers.

Haymaker seems to be worried by the difference in absolute zero as given by several writers. He says, "A single degree one way or the other doesn't look very big on paper, but get them into practice and watch the results."

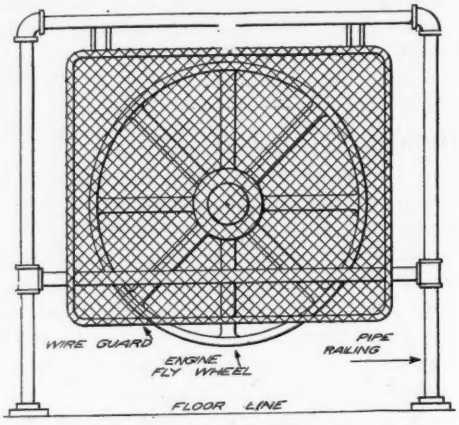
I think Haymaker is laboring under a false conception of absolute zero, since about the lowest temperature yet attained is —260 deg. C, and I feel sure he will not have anything like that to deal with in mechanical refrigeration, "on paper" being the only way absolute zero is dealt with, as it is calculated from the Law of Charles.

The French physicist Charles having discovered in 1786 that a gas will contract 1/273 of its volume at 0 deg C., for each degree Centigrade its temperature is lowered. It is obvious, therefore, that at —273 deg. C. its volume has decreased 273/273, losing its volume entirely. According to scientists, this is taken as absolute zero of temperature —273 deg. C. and by the well-known formula equals 459.4 deg. F. Some physicists use 1/273.1, which would give absolute zero at —273.1 deg. C. or —459.6 deg. F.; but since it is purely theoretical, and will not be met with in our present method of refrigeration, the two-tenths difference above, or the 6 deg. difference he refers to, will not put us out in our calculations as long as we use the same figure throughout the calculation of a formula. T. G. St. John.

Safeguarding Machinery in Factory Plants

The average factory owner or his manager is careful and anxious to see that all the machines in the factory are well guarded. Frequently, however, we find that some part of a machine or a pulley is guarded in such a way that there still is danger of somebody being injured or killed. These dangerous conditions are perhaps unknown to the factory owner or his manager.

A case of this kind is shown in the accompanying illustration. It will be noticed that only the upper part of the engine wheel is guarded; the lower part is not guarded in a safe way and there is danger of somebody falling near the wheel and getting his arm or leg into the wheel. It is an easy matter to pass by the wheel with



INSUFFICIENTLY GUARDED ENGINE WHEEL

a long rod or pipe and accidentally get this into the wheel with possible injury to oneself or somebody else.

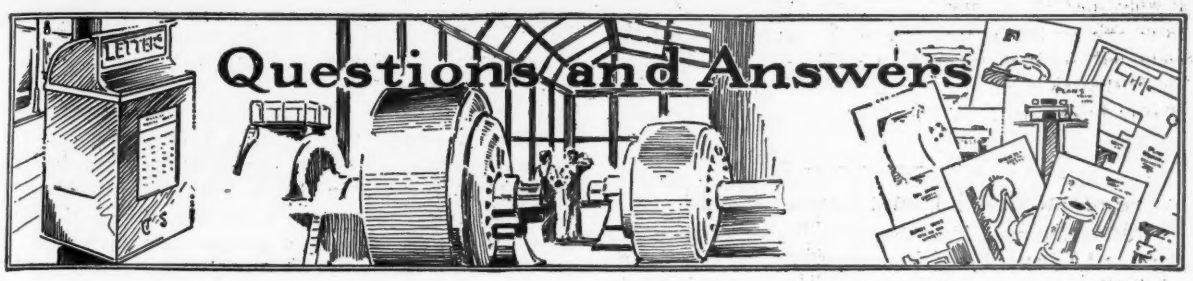
The remedy is to guard the entire wheel, or, still better, run the wire guard clear to the floor. In this way, all danger will be eliminated. H. A. Jahnke.

Demagnetizing a Watch

Last winter my watch became magnetized and caused me no end of trouble. Some days, it would lose only a few minutes; but on other days, it would, perhaps, lose half an hour or more, and I could not depend on it. I felt like a man going hunting without a gun. Having a desk fan handy, I removed the armature and laid the fan on the desk in a horizontal position. Next, taking the watch and tying a string to the ring about 2 ft. long and spinning the watch quite fast, I lowered it into the armature of the fan after turning on the current, not allowing the watch to stop spinning while it was in the armature. This happened about 3 mo. ago, and my watch is keeping as good time now as it ever did. I used alternating current at 110 v.

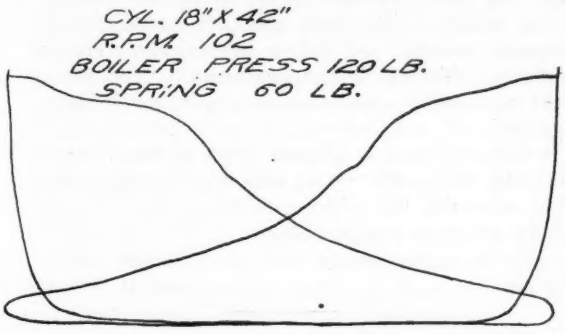
Harry H. Johnson.

The total number of lamps offered for delivery to the Government purchasing authorities during the past fiscal year was over 5,000,000, of which about 600,000, or 12 per cent, were rejected on the initial inspection at the factory, which covers the mechanical qualities of the lamps and their rating in regard to power consumption and efficiency. In this initial inspection samples are selected for the burning or so-called life tests. During the year nearly 3500 lamps were subjected to this life test, and with few exceptions the tungsten lamps, both vacuum and gas-filled, supplied under Government contracts, had a life considerably in excess of the 1000 hr. of burning required by the standard specifications.—Scientific American.



A Corliss Card for Criticism

THE ACCOMPANYING card was taken from an 18 by 42-in. Allis-Chalmers Corliss engine running at 102



CARD TAKEN FROM 18 BY 42-IN. CORLISS ENGINE

r.p.m. on 120 lb. steam pressure. I would like to have it criticized in Power Plant Engineering.

There is no trouble with the indicator.

C. R.

Massachusetts First Class License Questions

IN THE March 15 issue, page 355, some of the answers to questions by M. S. W. did not seem very clear to me.

The answer to question 10 states that it would probably be necessary to set the valve so as to cause earlier compression as the back pressure would be extremely low, and the engine would be likely to knock. This earlier compression is necessary in condensing, as the steam is escaping faster and the back pressure is lower. With the single eccentric, you can change the compression by adding lap to the exhaust valves, and then advancing the eccentric to make release early enough; but by doing this, you have shortened the range of cutoff, because you have had to add lap to the steam valve in proportion to the amount that the eccentric is advanced. The governor will take care of the cutoff. With a double eccentric engine, add a little lap to exhaust valves, and advance exhaust eccentric. By adding exhaust lap, release is later and compression is earlier. Advanced eccentric gives earlier release and earlier compression. By adjusting lap and eccentric, you can make the valve work properly. It is not necessary to change the cutoff on this if it will carry the load.

Question 11. What is the function of the lap on the steam valve of a Corliss engine? The answer given is that the lap governs the amount of steam supplied to the cylinder as well as the duration of admission. I consider that steam lap is put on a single eccentric Corliss engine so that the exhaust valves may have a chance to work properly, giving the proper compression. If there was no steam lap, the eccentric would have to be moved just the same for the exhaust to work right; this would bring the steam valves open, therefore steam valves must have lap to work properly. In the double eccentric type, the exhaust valves are controlled by a separate eccentric.

Question 13. In finding the maximum working pressure of a Manning boiler, you must consider more than the largest diameter of the shell. (Perhaps this refers to the outer shell of the firebox above the stay bolts. The shell at this point is reinforced by a continuous strap around the inside of the shell and riveted to the shell, which gives the necessary support.)

To find the maximum working pressure, the shell of the boiler and the stay-bolted surfaces are considered. The weakest of these will be the maximum working pressure, provided that the boiler is designed properly.

The strength of the shell = (tensile strength × thickness of plate × joint efficiency) ÷ (factor of safety × radius).

Pressure allowed on the stay-bolted surfaces is found as follows: load in pounds allowed on a given stay bolt ÷ net area supported by the stay bolt in square inches.

Question 18. The Ridgway engine does not have an exhaust steam governor; this is evidently a catch question. It has an inertia type governor, which controls the main valve of the pressure plate type. On compound engines, the high-pressure valve and low-pressure valve are operated by the governor, the low-pressure valve direct and the high-pressure valve by means of a tail rod connecting through an offset to the high-pressure rod.

W. N. L.

Water Rate of Engines

PLEASE give me the definition of "water rate" for steam turbines and steam engines.

Example: What is the meaning of the expression that the water rate of a steam turbine is 56?

A. N. G.

A. The water rate of a steam engine or a steam turbine refers to the number of pounds of water required to be evaporated per hour to supply the steam necessary for such an engine or turbine in the development of 1 hp.; that is, if the water rate of a steam engine is 25 lb., we understand that 25 lb. of water per hour are required to be evaporated for each horsepower developed by that engine.

Practically, this is the same as the steam rate. For each pound of water evaporated, 1 lb. of steam is produced.

We believe that this will answer your question as

to what may be the meaning of the expression that the water rate of a steam turbine is 56. We would understand that to mean that the particular turbine requires the evaporation of 56 lb. of water per hour for each horsepower developed by it.

Analysis of Lentz Engine Card

COMMENTING on Tom Jones' indicator diagrams in the April 1 issue, I find from drawings and description of the Lentz engine that both admission eccentric blocks are controlled by a common shaft actuated by the centrifugal inertia governor, so should act in unison although it is possible that internal wear may cause one valve to lift higher than the other. Test the valves for height of lift by baring over by hand.

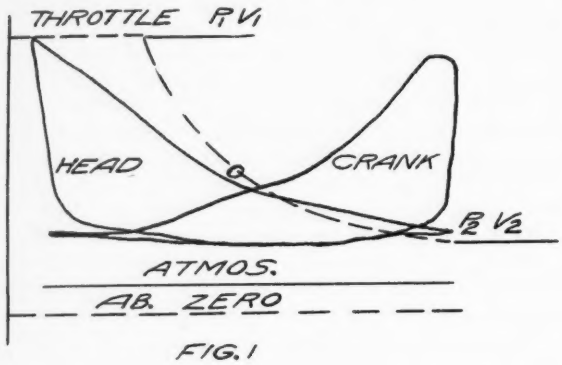


FIG. 1

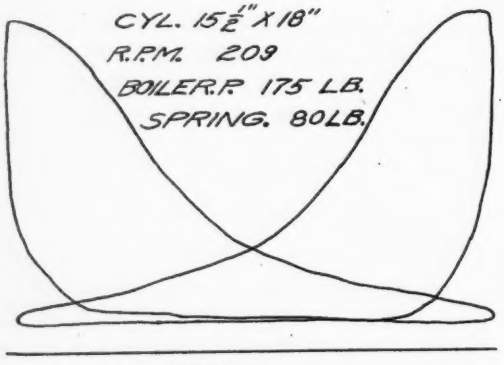


FIG. 2

FIG. 1. ORIGINAL CARD AS PRESENTED BY TOM JONES
FIG. 2. DIAGRAM TAKEN FROM A 15½ BY 18-IN. LENTZ ENGINE

The really serious feature of the engine is continued valve leakage. Try grinding the valves. Also see that the valve springs have sufficient tension to seat and hold the valve to the seat. Altogether it looks like a case of early valve closure and a bad leak. If the foregoing does not uncover the trouble, then look for a sand hole.

Note the diagram in Fig. 1, which is a copy of that given together with the addition of a $P V = K$ line or parabolic curve, a curve showing that as the volume increases after cutoff the absolute pressure falls. A 4 per cent clearance line is drawn and cutoff is assumed to occur at ¼ stroke. Note that the $P V = K$ dotted line and the actual line occur at a little later than half stroke. Planimetering the two lines, the $P V = K$ and the actual, shows that the actual gives 36 lb. m.e.p. and the $P V = K$ gives 44 lb. m.e.p. or an increase of nearly 22 per cent. Further note that the $P V = K$ line at end of expansion stroke is 7/16 in. above absolute zero while the actual line is ½ in. above the absolute zero, showing by volume that it takes 1/7 more steam by absolute pressure to do 18 per cent less work in the actual than it would in the theoretical. Still further remember that the leakage continues during the exhaust stroke, probably at a greater rate than during the expansion stroke because the pressure difference is greater. The compression line shows great leakage of the admission valve. While the pressure line at the crank end is almost vertical that at the head end is not. It slopes considerable, rising rapidly and thus showing that the added pressure is not from compression, but from leakage. Also note that a considerable rise in pressure occurs even before the exhaust valve closes entirely. Judging from appearances, I think the crank end will stand some attention with, probably, good results.

I am enclosing a diagram from an Erie City Lentz 15½ by 18-in., 209 r.p.m. with 175 lb. steam pressure. The expansion line will nearly follow the $P V = K$ line if the clearance line is added.

As an afterthought test the exhaust valves for leakage.

ROY R. WINANS.

How Can Wiredrawing be Eliminated?

REFERRING to the letter of Tom Jones in April 1 issue of Power Plant Engineering, I judge that the valve gear needs attention, as to bearings, pins, and stems, and possibly after an examination of the valves, and seats themselves it would be found that they need facing off. There is too much lead on the right hand steam valve which could be corrected by lessening it about half. Compression is too low on both ends for economical running. All the valves seem to show a shade of leakage.

H. W. ROSE.

Why the Knock?

SOME TIME AGO I experienced trouble similar to that related by J. L. S. on page 401 of the April 1 issue. It is therefore my opinion that as in my case his piston fails to fit his cylinder properly, which, accompanied by the presence of water (due to condensation of more or less wet steam), causes the knock complained of.

Properly fitting the piston and taking care to get steam as dry as possible will, I believe, eliminate the trouble.

R. H. WEST.

THE CAUSE of the knock is the piston dropping to the bottom of the cylinder on the forward stroke of the engine. When you took the sectional rings out, you found the springs broken. Put the sectional back and put in new springs that have tension enough to hold the rings out against the cylinder and I am sure you will not have any more trouble. You will notice, if you watch the governor to see when the load changes, that the knock will be more distinct.

Your card is very good; but, as you can see, in this case the indicator would not show you anything wrong, as the piston can not drop far enough to allow the steam to leak past it.

C. J. MILLER.

ON PAGE 401 of the April 1 issue, J. L. S. makes mention of a Corliss engine which is giving him much trouble, due to a persistent knock. In my opinion, this trouble is due to the sticking of the piston rings in their grooves and it is the sudden admission of the steam against the piston that causes the knock.

As a remedy, I should advise giving the rings more side play. A. A. HAMPSHIRE.

Criticism of E. B.'s Card

IN REGARD to the indicator card presented by E. B. for criticism on page 354 of the Mar. 15 issue, I would suggest that he increase the angle of advance until the admission line is perpendicular to the atmospheric line. On his card, these lines slant forward, showing that the admission of steam into the cylinder is too late.

I would also suggest that he relieve the back pressure on his engine. This is shown on the card by the height of the back-pressure line above the atmospheric line. A little back pressure does not do any harm, but I think E. B. has too much back pressure on his engine for the low gage pressure he carries. LESLIE KLOCK.

IN ANSWER to E. B. regarding his diagram, it looks as if it could be easily remedied. The admission is late and the exhaust is a little early. I think changes to correct these defects will make a great difference.

L. B. SHIELDS.

IN REGARD to the card submitted by E. B., I have these suggestions to offer.

The lead is quite late on both ends, which should be corrected. The compression on one end seems to be fair, but a little more could be given and get good results. The other end seems to have been rather neglected when the valves were adjusted for compression and should be given at least an amount equal to the other end and perhaps a little more than the other end now has. In this case, the release is late on both ends. The card shows that the crank end has a leaky steam valve which should be made tight at once.

I would like to see the card that is obtained in this case also, after the changes have been made.

FRED W. GOLDSMITH.

THE DIAGRAMS submitted by E. B. also show a late steam admission and late exhaust opening. Give the steam eccentric more lead, making the admission lines perpendicular to the atmospheric line. Both steam valves are in leaky condition, the right-hand diagram showing a very poor expansion line. This diagram also shows a greater back pressure, which is due to the steam valve leaking steam when closed.

The exhaust valves open too late; the eccentric could be moved to remedy this; but a good diagram will not be obtained until the valves are attended to.

TOM JONES.

Criticism of E. L. B.'s Card

REGARDING E. L. B.'s indicator card shown on page 354 of the Mar. 15 issue of Power Plant Engineering, I will say that it is a very irregular card to have been taken from such a slow speed engine. The loops on the compression lines are caused by the steam of compression leaking back past the piston, or through leaky exhaust valves. He might remedy this by putting in new piston rings, or by tightening up the exhaust valves.

The admission of steam into the cylinder is too late, as shown on the diagram by the admission line slanting forward. The remedy is to increase the angular advance until the admission line is perpendicular to the atmospheric line. LESLIE KLOCK.

THE CARD submitted by E. L. B. with request for criticism shows late admission on both ends. This type of engine has two eccentrics on the cam shaft, each of which lifts a steam valve, and if the eccentrics on both head and crank end are advanced on the cam shaft, you will find that instead of the loop you will get an earlier admission or, what is the same thing, a continuation of the compression line. That is all this engine needs. The right-hand card shows some steam leakage by the expansion line; but after the foregoing changes have been made all conditions will be improved.

A. C. WALDRON.

REPLYING TO the request of E. L. B., his cards from the 22 by 42-in. Brown engine show late compression and lead, the piston moving forward before steam is admitted, causing the drop in pressure indicated by the loop. I think increasing his angle of advance, thus giving increased lead, with earlier admission, cutoff, release and compression, will improve his card considerably.

FRANK L. WADSWORTH.

IN ANSWER to E. L. B., I wish to say that, from my experience, the loops in the admission lines of both ends are caused by the pressure being run up by compression to a point, then falling again as the piston starts on return stroke before the steam valve opens.

If the valves are such that they can be changed, I would suggest giving an earlier opening of the admission valves.

Excessive compression will cause a loop in the admission line, but not of this nature. In this case, I am sure earlier admission will remedy it. L. B. SHIELDS.

Operating Engine with Water Wheels

WE HAVE a Rice & Sargent 18 and 36 by 42-in. cross-compound condensing engine, running 124 r.p.m. in use with a load that varies from 250 to 900 hp. according to the supply of water for our water wheels. The engine is coupled with two Holyoke, horizontal, 39-in. wheels.

When the water is low, the engine is uncoupled and carries all the load. Should the load be divided evenly between the high and low pressure cylinders at all times?

What is the smallest load that would be safe to run on this engine? E. E. A.

A. The load should be equalized as nearly as possible between the high and the low pressure cylinders of a compound engine.

Provided your governor is in good condition, there is no limit to the smallness of the load which your engine could handle, as this depends wholly on the condition of your governor.

IF YOU have any time to kill, work it to death.

POWER PLANT ENGINEERING

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The Value of Management

Russia has tried the experiment of running industries without competent management in charge. All grades of workers were to be equal, and anybody was to manage, regardless of ability or experience. Even the leaders in the experiment are tacitly admitting its failure by calling back experienced men to take charge of operation of railroads and large industries. Excuses are made in the effort to cover the failure of the system, but the discontent and confusion among the great numbers of the workers has forced a change from the communist system and return to competent authority for direction of industrial organizations.

The need of management is established beyond question, but there is still the question of the value which is to be given to the services of those able to direct successfully, above the pay which they would receive as workers under the direction of others. What does management contribute to industry and production? And, by the way, how are the cost of production (chiefly labor cost) and the cost of living related?

In any given grade of labor, unskilled, skilled, mental or executive, wages will, in the long run, depend on supply and demand. Artificial pressure may alter conditions for a time, but not permanently. Many workers for few jobs means a low wage level; many jobs for few workers, a high level. But high wages means high cost of product, hence high prices and high living costs, and vice-versa.

Wages can be paid only from the return for the wealth produced by the workers, and if workers slack on the job to lessen production, either wages will be less or prices and the cost of living will be increased. This is too evident to need repeating, but does not seem to be taken to heart by many workers in the ranks of both managers and laborers.

To hold a steady balance, production of each necessity should be just sufficient to meet the needs of the community. If more is produced than people want, there is a glut of the market, prices will fall below the cost of production and wages will fall. Or, if wages are maintained artificially, production must cease or be reduced until the market has absorbed the surplus, and this means fewer jobs or a slowing down of the workers. In the latter case, cost of the product will again be increased, which will lessen demand and further reduce the need for workers. Carried to a finish, this means the shut-down of the factories.

Overproduction can best be regulated by controlling the amount of capital invested in production of any given necessity, which, in turn, will regulate the number of workers employed. Overexpansion of investment will ordinarily be corrected by excess of production, which results in shut-down; but this works a hardship to owners, managers and workers. Government interference does not seem desirable; but some remedy is needed, and this may possibly be found in the federation of the leaders in each industry, both employers and workers, to study the market and regulate expansion to meet demand. During a period of large temporary demand, there could be careful consideration of probable permanent demand before expanding manufacturing facilities. A short period of high prices might

be better than expansion to meet the temporary demand, followed by a period of idleness for men and machinery.

As to wages, they should obviously be sufficient to enable workers to live satisfactorily and provide for emergencies and old age; but moderate wages and steady employment are to be preferred to the "feast and famine" procedure which has marked our past industrial history. And, in fairness, the wages of a worker should be based on the value of what he produces. Why place a limit on the amount that a man shall be permitted to earn, or force him to give up to less ambitious and less faithful workers the increased results of his labor?

An able foreman will so plan the work for his men that production is greatly increased without increased effort. With fair division of return, the men will earn more and the employer will benefit; but surely the foreman is entitled to be paid for his ability in getting results.

A successful superintendent can so plan the methods and arrangement of the factory and the design of the product that greater amounts can be turned out with the same investment of capital and labor performed as before. Is he not entitled to generous reward in addition to what he would receive as a workman?

The manager who increases sales and reduces selling costs is widening the market, and providing additional jobs. He may return to the industry many times the value of his salary, besides making it possible to take advantage of the work of foremen and superintendent and to increase pay for workers. His compensation should be in proportion to his value to the organization, regardless of the fact that he may receive many times the pay of the worker in the ranks.

Now what does the worker contribute from the wealth that he produces as compensation for the benefits from competent management? George E. Roberts has shown that, in the U. S. Steel Corporation, if the salaries of executives, managers and selling force were taken from them and added to the wages of other employes, the average increase in wages for the employes would be 5 cts. a day. In the Bell Telephone System, if all who receive salaries over $5000 a year were cut to that figure and the amount saved distributed among those receiving less than $5000, the increase per employe would be 17 cts. a week. If the high limit of salary was made $1500, the increase to those getting under $1500 would be 64 cts. a week. It would seem that the amount paid for successful management is not excessive in comparison with the benefits derived, for certainly, without the incentive of adequate reward, men will not accept the responsibility and worry of the jobs now filled by the more highly paid executives.

The man who makes good is worth his pay, whether in shop or office. If he is not making good and is not worth what he receives, keeping him on the job is a wrong against his fellow-workers.

To be lasting, industry must turn out an honest product, which can only be done by honest, right thinking men. The spirit of the men will to a large extent be inspired by that of the management; hence the management is largely responsible for the honest foundation of right spirit and right production, on which success depends.

But right effort of the management cannot overcome persistent evil effort of obdurate workers. Each must practice what he wishes the other to practice, and strive as earnestly to perform his duties as to secure his rights. The Golden Rule, or its modern equivalent, "A Square Deal," must be applied both ways, if industries are to be put on a lasting and satisfactory basis, and the management which puts this into effect has a value to industry and to its own organization which is beyond estimate.

For the Benefit of Industry

Prior to but a few years ago the primary function of our technical institutes and the engineering colleges of our universities consisted of drilling young men in certain prescribed courses of study whereby they obtained a knowledge of the fundamentals of the various branches of engineering. The training was entirely theoretical. Gradually, however, it became evident that a need existed on the part of the student for an insight into at least some of the practical phases of the profession, and accordingly laboratory and shop courses were established. Such courses are now included in the curriculum of all engineering schools of recognition. Development along this line has, however, not ceased, for, in addition to the actual handling of tools and machinery in the school shops, many of our colleges have today in force so-called co-operative courses by means of which the student is allowed to spend a portion of his time in the various operating departments of manufacturing plants, public utilities, etc.

Wherever such courses have been tried, the results are most gratifying. The student's training is broader and more thorough and upon being graduated he is better able to determine his future course of specialization.

But what of industry? Especially in the case of state universities, industry contributes not a little to the maintenance of these schools, while the direct benefits thus far received are practically negligible, and it therefore appears desirable to provide arrangements for a greater degree of co-operation between the industrial and technical interests. True it is that already a number of institutions, such as the Engineering Experimental Station of the University of Illinois and the new Department of Industrial Research of the University of Michigan, have proven of much value to the industries of their respective commonwealths; however, other state schools might well follow the lead of these institutions and, in general, all such industrial research divisions might advantageously extend the scope of their activities to include all phases of power generation, transmission and utilization. Already the Bureau of Mines has been and is doing much along these lines, but, as its work is limited to the use of fuels, a broad field remains untouched. Together with the ever-increasing costs of plant operation and the more general use of labor-saving machinery, the question of economical and efficient plant operation becomes of vital importance to all. Nothing should remain undone to provide means to accomplish this, and surely our more well-equipped engineering schools are in an admirable position to carry on such work. In the majority of instances, proper organization is the only lacking element.

Most Powerful Electric Passenger Locomotives

SEVEN of the latest electric passenger locomotives being built for use on the electrified line of the Chicago, Milwaukee and St. Paul Railroad have already been shipped and six of these are already in operation. Over the section of country covered by this railroad, grades as great as 2.2 per cent for 18 mi. are encountered, and high powered locomotives are necessary to overcome them effectively. These locomotives, which are the largest and most powerful electric passenger locomotives, weigh 275 tons, and are rated at 4200 hp. for one hour and 3400 hp. for continuous operation. They have a maximum speed of 65 mi. per hour. On full field connection of motors, the tractive effort is 66,000 lb. for one hour and 49,000 lb. continuously.

Flexible control for passenger service is obtained by means of nine running speeds secured in three steps as follows: first, by connecting the six motors in series and then shunting their fields in two separate notches; and third, by connecting three motors in series, three in parallel and shunting the fields in two separate notches. For conserving energy down grades, regeneration can be accomplished at three different speeds.

Both safety and ease of control are obtained by placing the control apparatus in separate compartments in the cab so that all of the high-voltage apparatus is isolated from the low-voltage equipment. The main circuit high-voltage switches are of the unit-type and are electro-pneumatically operated.

ONE OF THE MOST POWERFUL ELECTRIC PASSENGER LOCOMOTIVES EVER BUILT

Electro-pneumatically operated switches are used on some of the low-voltage circuits and for reverser and change-over switches.

Four of the armatures of the motors or two complete motors are always connected in series across the 3000-v. energy supply so that normally there is never more than 750-v. between the brushes of each commutator. The motors are of the twin armature type, both armatures being geared to the same driving gear. The entire motor is mounted directly over the axle and is supported on the locomotive frame.

One of the distinctive mechanical features of these locomotives is the fact that the only non-spring borne weight on the tracks is that of the wheels, axles and journal bearings. This is accomplished by gearing the motors to the axles through quills which consist of hollow sleeves fitting around and concentric to the axles. Because this arrangement effectively eliminates the shock to the rails, it is considered to be a valuable improvement in electric locomotive drive.

Either pulling or pushing strains are taken care of between the two running gears by means of a long rigid link connecting them. However, all pulling or pushing strains are eliminated from the cab structure itself on account of floating center pin connection between cabs and trucks. The weight of the cab is carried on the pedestals which can be adjusted by shimming so as to distribute the weight of the cab as desired. An effect of standard three-point suspension is obtained by equalizing the center pin of the guiding truck with cross-equalization of the first pair of drivers, this combination forming the leading single point of suspension. The other two points of suspension are obtained by a side equalization of the two remaining drivers with the trailing pony truck. With the exception of helical springs, which are used on the Rushton truck, the spring arrangement is of the semi-elliptic type.

A wheel arrangement of 4-6-2-2-6-4 is obtained by connecting two trucks back to back. The two-wheel guiding trucks are of the Rushton type and have wheels 36 in. in diameter. The running gear equipment is so designed that each truck will guide itself independently of the leading truck.

In the center of the locomotive cab, is the train heating steam boiler which has a capacity of 4000 lb. of steam per hour. Adjacent to the boiler are water tanks and oil tanks having a capacity of 25,500 lb. of water and 750 gal. of oil respectively. The necessary auxiliary apparatus for the boiler is also located in the center space. The inclusion of all auxiliary apparatus and heating plant in a single cab greatly enhance the convenience and comfort of the operators.

On each inside axle of the Woodward trucks are the two axle-driven generators. These generators supply excitation for the main motors during regeneration, and are used to supply energy for the compressor and blower motor at all times during motoring.

Low-voltage control and energy for the auxiliary apparatus is supplied from a motor-generator set which has a storage battery floating across its terminals. This storage battery supplies energy for these circuits when the axle generator is not functioning.

An Automatic Valve for Sprinkler System

THE 3-WAY valve shown in Fig. 1, on which the inventor, J. Bloom, was recently awarded a patent, was designed primarily for use in connection with hydraulic presses. Its construction, therefore, is of a suitable type for high pressure work. The fact that it contains but few parts, and requires one cup packing only, in contact with the valve proper makes the valve of value in other lines of work, such as where freezing is likely to occur, through leaky packing.

The outer body of the valve consists of two castings, A and B, mounted rigidly on one base. Liner C fits inside of A and B, the joints being provided with packing and glands at the points shown. This liner is bored out taper to accommodate valve D. The pointed screw shown at the right is provided to force the valve forward in the liner as wear takes place. An extension is provided at the small end of the valve, to which to attach a handle for operation of the valve.

In the position shown, the valve is closed to the sup-

ply and provides a passage for the discharge of fluid from the press cylinders to the sewer or exhaust. When the valve is turned through 90 deg., ports E and F of the valve are brought into communication with ports G and H of the liner providing a passage through the valve body to the machine or press to be controlled, or the sprinkling system.

Bringing the valve back to the position shown puts ports K and L of the valve in communication with the annular spaces M and N through the large square ports

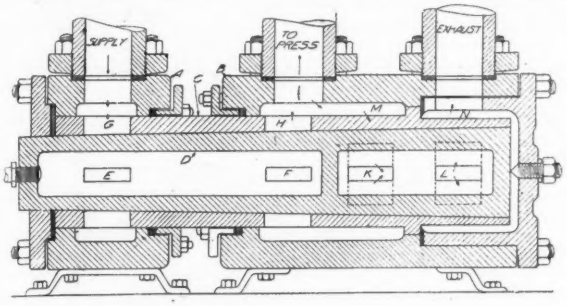

FIG. 1. SECTION THROUGH THE 3-WAY VALVE

shown dotted in the liner, providing an exhaust passage from the press, or sprinkling system.

Figure 2 shows in cross section an automatic operating mechanism for the valve shown in Fig. 1, for use in connection with a sprinkler system. Under normal conditions the sprinkler system is under air pressure, and when this pressure is lowered by the melting of a sprinkler head or by some other means, it is the office of this mechanism to open the valve in the high-pressure water main to the system.

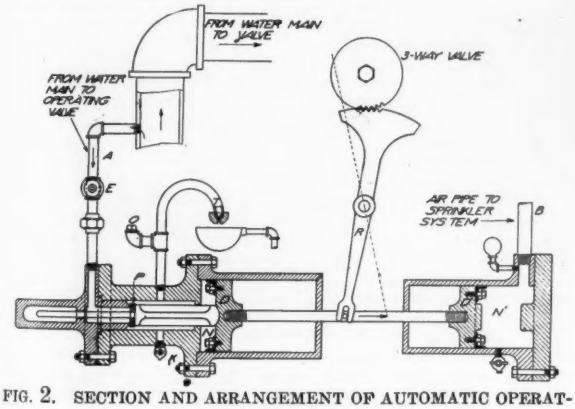

FIG. 2. SECTION AND ARRANGEMENT OF AUTOMATIC OPERATING MECHANISM

Pipe A provides communication between the left-hand chamber of the mechanism and the water pipe above the main valve. This allows a total pressure of about 300 lb. to be exerted on rubber disk P, which is 2 in. in diameter. From the right-hand cylinder pipe B connects with the sprinkler system in which 40 lb. air pressure is maintained. Piston D′ is 4 in. in diameter and, therefore, supports a total pressure of about 480 lb., 180 lb. more than that on disk P. The result is that P is kept in contact with its seat.

When the pressure in the sprinkler system falls sufficiently to reduce the pressure on D′ to less than 300 lb., P moves from its seat and admits water at 100 lb. pressure to cylinder N and piston D moves to the right, moving rocker arm R which admits water to the system.

When the need for the water no longer exists, the main valve is closed by the following operations: Closing valve E and opening pet-cock K, relieves the pressure in N and the piston is moved to the left by the pressure in N′. This closes the main water valve and opens the drain line from the sprinkler piping to the sewer. When air pressure has been restored to the system, valve E is again opened and cylinder N is filled with water through plugged opening O. As the piston D moves over in closing the main valve a part of the water which it displaces passes through relief-valve T which is held open by a light spring. This valve closes, however, when subjected to the velocity of water at 100 lb. pressure.

A New Portable Loader

DURING the time that labor was plentiful and cheap, the prevailing method of handling coal, sand, gravel, stone, etc., was to use a gang of laborers to handle the material from ground storage to cars or trucks. The increasing cost and scarcity of labor resulted in a number of labor-saving devices being introduced, among which was one consisting of a short, diagonal bucket conveyor mounted on a four-wheeled, self-propelled carriage. The disadvantage of this machine was its inability to feed itself into the pile of material to be handled.

THE NEW RADIAL LOADER, SHOWING THE SMALL RADIUS IN WHICH IT WILL OPERATE

A new, three-wheeled type of loader, which has been introduced by the same manufacturer, overcomes these defects. The new construction enables it to move forward or backward into the pile or to cut wide swaths across the pile by swinging alternately upon its driving wheels as pivots. This action is made possible by the use of a differential gear in the driving unit. The accompanying illustration of this type of loader shows clearly its ability to negotiate curves of small radius, the end of the discharge spout remaining at the same time practically stationary at the center of the circle, while the pick-up end of the conveyor traverses an arc or a complete circle.

Large, broad-tired wheels are provided so as to handle heavy materials over soft and rough or uneven ground. The boom carrying the buckets is readily adjustable to several positions. The 14 by 10-in. malleable iron buckets are provided with steel teeth on the front lips to minimize wear.

Speeds of 60 ft. per minute for traveling and 4 ft. per minute for feeding are provided. The capacity of a loader of this type is 1 cu. yd. per minute of 2½-in. crushed stone or 6-in. lump coal. The motive power is supplied by a gasoline engine or an electric motor.

Trade News

THE CLEVELAND OFFICE of Foster Engineering Co. is now at 1614 E. 40th St.

RUSSELL P. ASKUE has severed his connection with the Publicity Department of the National Lamp Works to go into agency work, with headquarters at Cleveland, Ohio.

THE FISHER GOVERNOR CO., of Marshalltown, Iowa, announces the removal of its New York office to 242 Lafayette St., New York City.

L. E. GEBHARDT, formerly connected with the Philadelphia sales office of the Yarnall-Waring Co., has been placed in charge of the Pittsburgh office, recently opened in the Fulton Building.

THE COMBUSTION ENGINEERING CORPORATION announces the resignation of its vice-president, in charge of sales, E. P. Moritz. Mr. Moritz had been ill for some time previous to his resignation and, owing to his continued ill health, it has been necessary for him to retire from active business for some time. No successor to Mr. Moritz has been named by the company up to date.

A BOOKLET entitled "A Hoist Below the Hook," which is illustrated by photographs of electric hoist installations in diversified services, is sent out by Shepard Electric Crane and Hoist Co., Montour Falls, N. Y.

LEAFLET NO. 6, lately received from the Griscom-Russell Co., 90 West St., New York, is designed for ready reference and briefly describes all of the apparatus manufactured by the company.

CLASSIFIED LIST of products exhibited by the International Exposition of Industries, Grand Central Palace, New York, was lately received.

SMOOTH-ON HOME REPAIRS is the subject of a new booklet illustrating a few of the repairs which can be made with Smooth-On iron cement, and divided into three sections; namely, household, automobile and garage floor. Smooth-On Mfg. Co., Jersey City, N. J., is the manufacturer.

HANDLING OF COAL from railway car to bunker or storage pile is an ever present problem with many power plant executives. The latest equipment designed to meet this problem is the American Trolley Carrier which is completely described in a catalog just issued. The equipment consists of an overhead trolley, operated on either a monorail track or suspension cable. A hoist is used to lower and move a one-ton, self-dumping bucket, in which the material is carried, one man handling the carrier in all its operations—loading, hoisting, conveying, dumping and returning the bucket, an average of 30 tons of coal being handled an hour.

Copies of the catalog, entitled "The American Trolley Carrier," and published by American Steam Conveyor Corporation, 326 W. Madison St., Chicago, will be sent to interested readers on request.

THE GRISCOM-RUSSELL CO., 90 West St., New York City, has just issued Bulletin No. 1140, devoted to the Stratton Steam Separator.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of Aug. 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for April 1, 1920.

State of Illinois } ss.
County of Cook }

Before me, a Notary in and for the State, DuPage and County aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and, if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, None.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
A. E. Rice, Wilmette, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association or corporation has any interest, direct or indirect, in the said stocks, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is.

(This information is required from daily publications only.)

Charles Sanford Clarke, Secretary.

Sworn to and subscribed before me this 27th day of March, 1920. Warren A. Lathrop, Notary Public.

(SEAL) (My commission expires Oct. 16, 1922.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed next after its filing.